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Superfund Innovative Technology Evaluation Program: Progress and Accomplishments, Fiscal Year 1989. A Third Report to Congress

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The Superfund Innovative Technology Evaluation Program

Progress And Accomplishments Fiscal Year 1989

A Third Report To Congress

SITE

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TECHNOLOGY EVALUATION

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This document is the third Report to Congress on the Superfund Innovative Technology Evaluation (SITE) Program. This report summarizes the progress, accomplishments, and results of the SITE Program through 1989. Field demonstrations for eight projects have been completed since publication of the first report. The second Report to Congress focuses on the completed demonstrations and provides performance data and results. The process used to assess the economic feasibility of each demonstration is presented. This report also describes the progress of the components that were initiated during the first year of the program and the two components implemented during this past year. Another difference between the two reports is that the second Report to Contress idientifies the impediments encountered during the first 3 years of the program and describes the refinements that EPA has implemented to address these problems and improve the effectiveness of the SITE Program.

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THE SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION PROGRAM

PROGRESS AND ACCOMPLISHMENTS
Fiscal Year 1989

A Third Report To Congress

Office of Solid Waste and Emergency Response
Office of Research and Development
U.S. Environmental Protection Agency
Washington, DC 20460

PREFACE

This document is the third Report to Congress on the progress and accomplishments of the Superfund Innovative Technology Evaluation (SITE) Program. The first Report to Congress, published in February 1988, described the regulatory authority and process for establishing the SITE Program. The first report was prepared prior to completion of the program's first technology demonstration so no results were available. The second Report to Congress focused on the completed demonstrations and summarized the performance data and results for seven technology demonstrations. This report described the progress and accomplishments of the components that were initiated during the first year of the program and the two components implemented during the second year. The second report also identified the impediments encountered during the first two years of the program and described the refinements that EPA has implemented to address these problems and improve the effectiveness of the SITE Program. These concerns were also addressed in the *Management Review of the Superfund Program.* Activities to implement the review's recommendations are discussed in this third report.

The third Report to Congress reports the progress and accomplishments for each of the SITE Program components. Although this report is similar in scope to the second Report to Congress, there are some significant differences in format. The format of the section reporting the progress and accomplishments of the SITE Demonstration Program has been changed. The first two reports organized the demonstration projects chronologically by solicitation number. This report has organized the demonstration projects by type of treatment technology (e.g., thermal, biological, solidification/stabilization, chemical, and physical). Within each major treatment category, the technologies have been separated into subcategories, and brief descriptions of these different treatment processes are included. Demonstration technologies were then grouped under each treatment subcategory, as applicable, to facilitate comparison of various treatment technologies.

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EXECUTIVE SUMMARY

The Superfund Amendments and Reauthorization Act of 1986 (SARA) directs the Environmental Protection Agency (EPA) to establish an "Alternative or Innovative Treatment Technology Research and Demonstration Program" and to submit an annual report to Congress describing the progress and results of this program. In response to this mandate, EPA established the Superfund Innovative Technology Evaluation (SITE) Program to: (1) accelerate the development, demonstration, and use of new or innovative treatment technologies and (2) demonstrate and evaluate new, innovative measurement and monitoring technologies. The strategy and program plan for the SITE Program was published in December 1986, and the progress and accomplishments of the program were first reported to the United States Congress in February 1988 and again in March 1989.

This document is the third report to Congress on the progress and results of the SITE Program. This report presents a brief history of the program and the statute that authorized its establishment. The report includes an overview of the four components of the SITE Program, and describes the process, progress, results, and future activities for each of these components. The major accomplishments for each component of the SITE Program are highlighted below.

SITE Demonstration Program. The SITE Demonstration Program was established to develop reliable performance and cost information on innovative alternative technologies that could be used in remediation decision-making for hazardous waste sites.

The 38 technologies presently active in the SITE Demonstration Program represent five process categories. There are currently seven thermal, five biological, nine solidification/stabilization, four chemical, and thirteen physical technologies in the program. To date, EPA has completed 14 technology field demonstrations.

The major accomplishments of the SITE Demonstration Program in FY 1989 include:

- Twelve new technology developers were accepted into the SITE Demonstration Program under the fourth solicitation cycle.
- Seven demonstrations were completed.
- At least 10 technologies are now in the planning stages for field demonstrations.
- Twelve reports, including eight *Technology Evaluation Reports* and four *Applications Analysis Reports*, were published on eight of the completed demonstrations. Eleven additional reports are in different stages of preparation and review.

Emerging Technologies Program. This program was established to promote the development of innovative alternative technologies. Laboratory bench- and pilot-scale technologies that are not yet ready for field demonstration are evaluated for their potential for future field use. The Emerging Technologies Program assures that technologies can be tested early in their development, and that promising technologies can "feed" into the Demonstration Program. There is currently a total of 15 bench- and pilot-scale technologies in the program.

The major accomplishments of the Emerging Technologies Program in FY 1989 include:

- Results to date were sufficiently encouraging to warrant approval for second-year funding for five of the projects from the first solicitation.
- Seven new bench- or pilot-scale technologies were accepted from the second solicitation, and one additional technology was accepted from the first solicitation.
- EPA has evaluated 47 preproposals submitted in response to the third solicitation issued in July 1989.

Monitoring and Measurement Technologies Program. This component of the SITE Program was designed to improve Superfund site characterization efforts through the development of new and innovative monitoring and measurement technologies. The Monitoring and Measurement Technologies Program (MMTP) has both an emerging technologies and a field demonstration component. In prior years, the MMTP concentrated predominantly on laboratory research that focused on the developmental stage of monitoring and measurement technologies. The MMTP is now moving toward the field demonstration of monitoring and measurement technologies that have progressed beyond the development stage.

During FY 1989, the first two monitoring and measurement technologies were demonstrated at Superfund sites. These two technologies were:

- A field immunoassay kit and a laboratory-based immunoassay for measuring pentachlorophenol in groundwater, and

- Canister-based samplers and long-path optical system (high resolution Fourier-transform infrared spectrometer) for monitoring toxic organics in ambient air.

It is anticipated that three to five additional monitoring and measurement technologies will be funded for demonstration in 1990.

Technology Transfer Program. Comprised of numerous components that incorporate a variety of outreach activities, this program disseminates demonstration and waste remediation data from all components of the SITE Program to regional and state managers of Superfund cleanup activities, federal agencies, the engineering community, related industries, and the public.

The major accomplishments of the Technology Transfer Program during FY 1989 include:

- Numerous publications were prepared and disseminated including eight *Technology Evaluation Reports*, four *Applications Analysis Reports*, six SITE videos, two program status brochures, numerous project fact sheets and bulletins, and technical papers and posters.

- EPA sponsored an international forum on innovative hazardous waste treatment technologies that was attended by over 530 representatives of the United States and seven other countries. The purpose of the conference was to introduce promising international technologies through technical papers and poster displays, and to discuss the status and results of SITE Program technologies.

- The ATTIC system became operational in May 1989. Over 400 copies of the database have been distributed, and over 150 requests for information have been processed. The ATTIC system was made available online in November 1989.

- EPA and the Department of Energy (DOE) signed a Memorandum of Understanding to conduct a joint demonstration under the SITE Program at a DOE facility contaminated with mixed radioactive and hazardous waste.

- A Regional SITE Coordinator's Meeting was held to identify potential demonstration sites for new technologies entering the SITE Program.

- Visitor's Days were held to observe field activities for six demonstrations and attendance ranged from 30-135 visitors.

A major focus in the upcoming year will be the field demonstration of the 24 technologies in the SITE Demonstration Program that remain to be demonstrated. Efforts will be directed to continue to expedite the report preparation process and to provide interim results. The fifth solicitation will be released in January 1990. Evaluation of the 15 laboratory bench- and pilot-scale technologies in the Emerging Technologies Program will continue during FY 1990. Final selection of an expanded number of emerging technologies accepted into the program under the third solicitation will be completed in March 1990. The fourth solicitation for emerging technologies is expected to be published in July 1990. Demonstration reports for the two monitoring and measurement technology demonstrations will be available in the coming year. Technology transfer activities will continue for the technologies that are currently in the program and will be initiated for the new technologies entering the program in FY 1990 under the SITE Demonstration Program and the Emerging Technologies Program.

I. INTRODUCTION

A. STATUTORY AUTHORITY

The Superfund Amendments and Reauthorization Act of 1986 (SARA) (Section 209(b)) amends Title III of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) by adding Section 311 which directs the Environmental Protection Agency to establish an "Alternative or Innovative Treatment Technology Research and Demonstration Program" and to submit a report to Congress annually on the progress and results of this program. As required in Section 311(e), this report presents the program's accomplishments through Fiscal Year 1989 and is the third annual report to Congress.

In response to SARA, EPA has established a formal program to: (1) accelerate the development, demonstration, and evaluation of new or innovative treatment technologies, (2) demonstrate and evaluate new, innovative monitoring and measurement technologies, and (3) disseminate information concerning the performance and applicability of these innovative treatment technologies to facilitate their use in providing more permanent remedies at contaminated sites. This program is called the Superfund Innovative Technology Evaluation (SITE) Program. The strategy and program plan were published in December 1986, and the progress and accomplishments of the program were first reported to the United States Congress in February 1988 *(The Superfund Innovative Technology Evaluation Program Progress and Accomplishments: A Report to Congress*; EPA/540/5-88/001), and then reported again in March 1989 *(The Superfund Innovative Technology Evaluation Program: Progress and Accomplishments Fiscal Year 1988*; EPA/540/5-89/009).

The overall goal of the SITE Program is to "carry out a program of research, evaluation, testing, development, and demonstration of alternative or innovative treatment technologies ... which may be utilized in response actions to achieve more permanent protection of human health and welfare and the environment." Specifically, the goal of the program is to maximize the use of alternatives to land disposal in cleaning up Superfund sites by encouraging the development and demonstration of new, innovative treatment and monitoring technologies. SARA defines "alternative technologies" as "those technologies, including proprietary or patented methods, which permanently alter the composition of hazardous waste through chemical, biological, or physical means so as to significantly reduce the toxicity, mobility, or volume (or any combination thereof) of the hazardous waste or contaminated materials being treated. The term also includes technologies that characterize or assess the extent of contamination, the chemical and physical character of the contaminants, and the stresses imposed by the contaminants on complex ecosystems at sites." Under the SITE Program, alternative technologies are classified by their development status as follows:

- Available Alternative Technology. Technologies, such as incineration, that are fully proven and in routine commercial or private use.

- Innovative Alternative Technology. Any fully developed technology for which cost or performance information is incomplete, thus hindering routine use at hazardous waste sites. An innovative alternative technology requires field testing and evaluation before it is considered proven and available for routine use.

- Emerging Alternative Technology. An emerging technology is one in an earlier stage of development; the research has involved laboratory testing and is being developed for pilot-scale prior to field testing at Superfund sites.

The development process for alternative technologies proceeds through four stages--lab scale development, pilot scale-up, field demonstration, and evaluation and technology transfer. Emerging technologies are generally those technologies in the lab scale development and the pilot scale-up stages. Innovative technologies include those technologies in the pilot scale-up stage that show promise of being scaled-up rapidly to full scale following pilot-scale testing, and those technologies that are developed and ready for full-scale field demonstration. Technologies are ready for commercialization following the demonstration and evaluation stage. Available technologies are those technologies in the technology transfer stage--they have been tested and evaluated, performance data is available, and they are commercially available.

The SITE Program assists technology developers in the development and evaluation of new and innovative treatment technologies, and thus enhances the likelihood that these technologies will eventually be commercially available and used at hazardous waste cleanup sites as alternatives to land-based containment systems presently in use. The program consists of the following major objectives:

- To conduct and monitor demonstrations of promising innovative technologies to provide reliable performance, cost, and applicability information for future site characterization and cleanup decision-making.

- To identify and remove informational impediments to the use of alternative technologies.

- To encourage the development of emerging alternative technologies.

Section 121(b) of CERCLA states a preference for treatment technologies that permanently reduce the volume, toxicity, or mobility of the hazardous substances, pollutants, or contaminants. The SITE Program focuses on the development, demonstration, and evaluation of such technologies. Section 209(b) of SARA authorizes EPA to establish a field demonstration program for testing innovative treatment technologies at Superfund sites. The demonstrations conducted under the SITE Program utilize actual wastes to better evaluate the performance of the technologies in the field.

The SITE Program also supports the development and testing of improved monitoring and measurement technologies to be used at Superfund sites. This component of the program is intended to improve capabilities in site assessment, measuring the extent of contamination, as well as measuring the effectiveness of a demonstrated technology.

Recognizing that access to accurate, pertinent information is essential to the acceptance and use of alternative technologies, Section 311(b)(8) of CERCLA also directs EPA to "... conduct a technology transfer program including the development, collection, evaluation, coordination, and dissemination of information relating to the utilization of alternative or innovative treatment technologies for response actions..." The statute requires the Agency to establish and maintain a technology transfer program that is directed toward disseminating reliable, current information on the performance, cost, and applicability of innovative treatment technologies to facilitate their use in remediating contaminated sites. As described in Section V of this report, EPA has established an information center to ensure that program findings, as well as other treatability data, will be available to the Agency and other parties responsible for remediation decisions and activities at hazardous waste sites.

This report documents the progress made by the SITE Program through Fiscal Year 1989. It also summarizes continuing activities. The report includes an overview of the development of the SITE Program and its components; recommendations for the SITE Program from the *Management Review of the Superfund Program*; and the progress, accomplishments, and planned activities for each of the four major components of the SITE Program.

B. HISTORICAL PERSPECTIVE

Prior to the enactment of SARA, concern had been growing among the scientific community, citizens, and government officials over: (1) the effectiveness of conventional methods for managing hazardous wastes at Superfund sites in protecting human health and the environment, (2) the tremendous costs associated with remediating contaminated sites, and (3) the increasing volume of hazardous wastes being generated which requires disposal. Land disposal is not the best solution for much of the hazardous waste present at these sites, and for some wastes it is prohibited as a disposal option. The need for reliable, cost-effective treatment solutions that offer more permanent remedies has been stressed by numerous studies and recent legislation. In addition to the preferences for waste treatment contained in SARA, the Hazardous and Solid Waste Amendments (HSWA) of 1984 (reauthorization of the Resource Conservation and Recovery Act) imposed additional prohibitions on land disposal of most hazardous wastes, effective August 8, 1988. These restrictions affect nearly one-third of all hazardous wastes regulated by EPA and may require treatment of many Superfund wastes that previously might have been placed untreated into land disposal units. Additional prohibitions on the second third of remaining wastes were imposed on June 8, 1989. Final rules to be published by May 8, 1990, will restrict the disposal of all hazardous wastes regulated by EPA under HSWA.

The scientific and engineering communities recognized that the demand for treatment often exceeded the availability and capability of existing technologies. Studies have concluded that research, development, and demonstration (RD&D) devoted to innovative cleanup technologies were inadequate. The Science Advisory Board to EPA also recommended that the Agency embark on a comprehensive research program to investigate more effective, permanent solutions.

In response to these growing concerns, EPA moved ahead in early 1986 to establish a technology demonstration program. A strategy was developed to lay out the problems, impediments, and possible solutions relative to the increased use of innovative treatment technologies at Superfund sites, prior to the enactment of SARA. This strategy formed the foundation of the SITE Program.

C. SITE PROGRAM COMPONENTS

The SITE Program has evolved over the past three years into a program consisting of four major components. Each component was designed to address specific information needs to foster the use of innovative alternative technologies and/or eliminate impediments that inhibit their use in treating hazardous wastes.

There are a number of impediments inhibiting the acceptance and use of alternative technologies for the treatment of hazardous wastes at Superfund sites. These technologies often have not had the opportunity to be proven effective on a commercial scale or have not been used for specific applications at hazardous waste sites. As a result, it is difficult to assure potentially responsible parties, site owners, and the affected community that technologies that have not undergone field-scale demonstration will be effective in remediating a site. A key component of the SITE Program is the removal of these informational impediments by supporting demonstrations that will provide reliable performance and cost data.

To foster this comprehensive program for the development, acceptance, and utilization of new and improved technologies, the SITE Program includes the following four components:

- SITE Demonstration Program
- Emerging Technologies Program
- Monitoring and Measurement Technologies Program
- Technology Transfer Program.

1. SITE Demonstration Program

One of the most important aspects of the SITE Program is the evaluation of the demonstrations of full-scale technologies or pilot-scale technologies that can be scaled-up for commercial use. The Demonstration Program has been the primary focus of the SITE Program because these technologies are close to being available for selection in remediation of Superfund sites, and offer the greatest potential for impacting the use of these technologies. The major objective of the SITE Demonstration Program is to develop extensive performance engineering and cost information on innovative alternative technologies so that they can be adequately considered in remediation decision-making for hazardous waste sites. The demonstrations are designed to provide information to assist potential users in making sound judgments as to the applicability of the technology for a specific site and particular wastes, and to compare the technology's effectiveness and cost to other alternatives. The results of the demonstrations identify the limitations of the technology, the potential need for pre- and post-processing of wastes, the types of wastes and media to which the process can be applied, the potential operating problems, and the approximate capital and operating costs. The demonstrations also permit evaluation of long-term risks. Demonstrations usually occur at Superfund sites, and involve wastes that are typically encountered at these sites to assure the reliability of the information collected and acceptability of the data by users.

Developers are responsible for demonstrating their innovative systems at selected sites and are expected to pay the costs to transport equipment to the site, operate the equipment onsite during the demonstration, and remove the equipment from the site. EPA is responsible for project planning, sampling and analysis, data quality assurance and quality control, report preparation, and information dissemination. If the developer is unable to obtain financing elsewhere, in some instances, EPA will consider bearing a greater portion of the total project cost. The demonstrations enable EPA to assess the performance, reliability, applications, limitations, and costs of new and innovative technologies. This information can then be used in conjunction with existing data to select the most appropriate technologies for the cleanup of existing Superfund sites. There are currently 38 active technologies in the SITE Demonstration Program. Of these, 14 technology demonstrations have been completed, and EPA is working with the developers of the remaining 24 technologies in preparing for their demonstrations. At least ten demonstrations are in the planning stages for field demonstration. The progress and accomplishments for the SITE Demonstration Program are described in Section II.

During the first three years of the SITE Program, EPA has gained valuable insight into management and implementation of all aspects of the SITE Demonstration Program. The Agency continues to incorporate refinements in the demonstration process, including establishing policies, guidelines, and procedures to streamline and improve technology selection, site selection, demonstration planning and implementation, and preparation and dissemination of the demonstration and applications reports.

2. Emerging Technologies Program

This component of the SITE Program involves bench- and pilot-scale evaluation of technologies or approaches that are not ready for full-scale demonstration. Its goal is to ensure that a steady stream of improved, innovative technologies will be ready for scale-up in the Demonstration Program, thereby increasing the number of viable alternatives available for use in Superfund site remediations. The Emerging Technologies Program incorporates innovative technologies for recycling, separation, detoxification, destruction, and solidification/stabilization of hazardous constituents and materials handling technologies. Candidate technologies must show promise at the bench/laboratory-scale. It is anticipated that the most successful emerging technologies will "feed" into the SITE Demonstration Program for field demonstration and evaluation. Unlike the SITE Demonstration Program, the projects in the Emerging Technologies Program are cooperatively funded by EPA. There are currently 15 active projects in the Emerging Technologies Program, and the progress and accomplishments for the program are presented in Section III.

3. Monitoring and Measurement Technologies Program

This component of the SITE Program is designed to support Superfund site characterization efforts by furthering the development of innovative monitoring and measurement technologies. EPA laboratories are exploring new and innovative technologies that will permit improved assessment of the extent of contamination, characterization of contaminants, and evaluation of remedial/removal activities at hazardous waste sites. The four goals for effective monitoring and measurement technologies at Superfund sites include: (1) to assess accurately the degree of contamination at a site, (2) to provide data and information to determine impacts to health and the environment, (3) to supply data for the selection of the most appropriate remedial action, and (4) to monitor the success/failure or effectiveness of a selected remedy. Through the enactment of SARA, EPA has been provided with a mechanism specifically aimed at supporting monitoring technologies at Superfund sites. The Monitoring and Measurement Technologies Program focuses only on technologies that detect, monitor, and measure hazardous and toxic substances in air, surface water, groundwater, soil, subsurface (saturated and vadose) zones, wastes, and biological tissues. The progress and accomplishments of this program are presented in Section IV.

4. Technology Transfer Program

The Technology Transfer Program encompasses a variety of public outreach and information dissemination activities that support the SITE Program. These efforts are integral components of the program and are essential to its success. Dissemination of data from demonstrations conducted under the SITE Program and access to existing hazardous waste remediation data are the key to increasing the use of alternative technologies at Superfund sites. The overall purpose of the technology transfer activities is the development of an interactive communication network with those requiring up-to-date technical information and assistance to ensure that they receive needed information in a timely, convenient manner.

The Technology Transfer Program is composed of numerous components that incorporate a variety of activities, including:

- SITE Reports, Videos, Brochures, and Publications
- International Meetings
- Clearinghouses (Alternative Treatment Technology Information Center, OSWER Bulletin Board, and Technical Information Exchange)
- Cooperative Efforts with Other Federal Agencies
- Seminar Series
- Public Meetings and Demonstration Site Visits.

The various activities that have occurred and publications that have been prepared under the Technology Transfer Program are described in Section V.

D. MANAGEMENT REVIEW OF THE SUPERFUND PROGRAM

1. Overview of the Report

In response to questions concerning the achievements of the Superfund program over the past nine years and its future management, EPA conducted a management review of the program. Completed in approximately 90 days, the review comprises facts, observations, and interpretations drawn from EPA staff and from a variety of critics and supporters outside of the Superfund program. The 50 recommendations resulting from this assessment were published in June 1989 in a report entitled *A Management Review of the Superfund Program* (referred to as the 90-Day Study). This candid report sets forth a practical, long-term strategy for the Superfund program and has received broad acceptance both from within and outside the Agency. One of the key elements of the study, directly related to the SITE Program, focused on seeking new technologies for more effective cleanup. The study recommended that the Agency expand its research, and provide more comprehensive field support for the development and use of treatment technologies to promote permanent solutions.

The 90-Day Study strongly supports the SITE Program and presents recommendations aimed at strengthening it to more fully satisfy technology information and development needs. The study challenges EPA to invest more heavily in the development and use of treatment technologies to bring about permanent remedies in the field and identifies opportunities for further research. The major findings of the study concerning the SITE Program were that the program needed to further expand the range of available technologies and that information from completed demonstrations should be produced and disseminated more rapidly.

The six major recommendations in the report relative to the SITE Program are to:

(1) Evaluate performance and cost of technologies already being used at Superfund sites.

(2) Conduct additional demonstrations of innovative technologies.

(3) Support development of emerging laboratory- and pilot-scale technologies.

(4) Evaluate combinations of technologies in addition to individual technologies.

(5) Provide rapid reporting of demonstration results through performance bulletins and by placing results in an information clearinghouse and by reducing production time for full reports.

(6) Suggest ways to eliminate internal barriers to the introduction of new technologies into the Superfund program.

EPA developed an Implementation Plan in September 1989 to describe and assign responsibility for the activities to be carried out in response to the recommendations of the 90-Day Study.

2. Actions to Implement Recommendations

The Agency has taken immediate steps to review and implement the six recommendations in the 90-Day Study related to the SITE Program. A brief description of these actions is presented below.

Evaluate Performance and Cost of Technologies Already Being Used at Superfund Sites. Selected new innovative and available technologies, that are not SITE demonstrations but are being used at Superfund sites as the permanent remedy selection, will be evaluated. EPA will identify candidate technologies by March 1990. The first evaluation will begin in late 1990, and will include the performance of the technology, especially in the areas of process reliability, cost, and applicability to other sites and wastes.

Conduct Additional Demonstrations of Innovative Technologies. Opportunities exist to evaluate and support technologies that are not already in the SITE Program. Both the Department of Defense (DOD) and the Department of Energy (DOE) are working with EPA on treatment technology evaluations. For example, EPA has initiated discussions with the Department of Energy to conduct a cooperative EPA/DOE SITE Program demonstration evaluation on mixed or low-level radioactive waste. Several planning meetings have been held to identify potential DOE sites for the demonstration. EPA and DOE signed a Memorandum of Understanding in December 1989. It is anticipated that a joint EPA/DOE demonstration evaluation will be conducted in the summer of 1990.

There is also a need to expand the range and types of technologies that are currently participating in the SITE Program. While thermal and solidification technologies are well represented, others such as biological, chemical, and physical treatment technologies are not. EPA will initiate special outreach efforts to bring other types of technologies into the program.

Support Development of Emerging Laboratory- and Pilot-Scale Technologies. One of the goals of the Emerging Technologies Program is to ensure that a steady stream of improved, innovative technologies will be ready for scale-up in the Demonstration Program. Thus, EPA will expand the number of emerging technologies accepted into the program in FY 1990 in order to accelerate the future potential of these technologies as candidates for the Demonstration Program.

Evaluate Combinations of Technologies in Addition to Individual Technologies. Currently, the majority of the SITE Program evaluations are individual technologies, but often in the remedial design phase of the permanent remedy selection combinations of two or more technologies are necessary. For example, the two BioTrol technologies in the SITE Program combine a soil washing system and a biological treatment system. At the SITE demonstration evaluation test, the soil washing technology cleaned soils contaminated with PCP and creosote. The process water, resulting from the soil washing treatment system, was then treated biologically in a fixed-film bioreactor to remove PCP and cresote contaminants.

Provide Rapid Reporting of Demonstration Results through Performance Bulletins, and by Placing Results in an Information Clearinghouse, and Reduce Production Time for Reports. In October 1989, EPA completed a review of the current SITE Program information transfer process to identify ways to accelerate reporting of demonstration results. Based on this review, a revised reporting system is being developed and will be implemented by January 1990.

Suggest Ways to Eliminate Internal Barriers to the Introduction of New Technologies into the Superfund Program. In response to this recommendation, in early 1990, EPA will meet with the developers who have completed SITE demonstrations to identify internal constraints they have experienced during their participation in the SITE Program. Based on these meetings, EPA will identify by June 1990 changes to the SITE Program to facilitate the demonstration and commercialization of new innovative technologies.

The 90-Day Study also recommended that EPA establish an information clearinghouse containing data, reports, and references from EPA, states, and other evaluations of technology performance. It was further recommended that the clearinghouse include a computerized database that allows access through telephone inquiry, online computer access, and printed material. EPA has implemented the ATTIC system to give users easy access to information on alternative treatment technologies to encourage their use in remediating contaminated sites.

The remaining sections of this report present the FY 1989 accomplishments and FY 1990 future activities for the SITE Demonstration Program, Emerging Technologies Program, Monitoring and Measurement Technologies Program, and the Technology Transfer Program.

II. THE SITE DEMONSTRATION PROGRAM

Based on the emphasis placed on demonstrations in Section 311(b) of CERCLA, the Demonstration Program has been the primary focus of the SITE Program. Now in its third year, the SITE Program is providing data on alternative treatment technologies necessary to implement new federal and state cleanup requirements that are aimed at permanent remedies rather than land disposal.

This section addresses the implementation process and the FY 1989 progress and accomplishments for the SITE Demonstration Program.

A. SITE IMPLEMENTATION PROCESS

The procedures developed and the activities that have been performed under each of the major steps of the SITE demonstration process are briefly discussed in the following sections.

1. Selection of Technologies

EPA has developed implementation procedures to ensure that the SITE Demonstration Program encourages developer participation, gathers required data, and provides adequate safeguards for human health and the environment. This process includes the following major steps:

- Selection of technologies for participation.
- Selection of sites for the demonstrations.
- Establishment of cooperative agreements with developers.
- Development and implementation of community relations activities.
- Preparation of detailed plans for the demonstration.
- Demonstration of the technology and preparation of reports on the demonstration results.
- Estimation of technology implementation costs.

Technologies are accepted into the program through an annual solicitation published in the *Commerce Business Daily*. Preproposal conferences are held at various locations around the United States to give potential responders the opportunity to discuss the purpose, scope, and process of the SITE Program with EPA personnel. In response to the solicitation, technology developers submit proposals to EPA addressing the following selection criteria:

- *Technology Factors*. Description of the technology and its history; identification of effective operating range; materials handling capabilities; application to hazardous waste site cleanup; mobility of equipment; capital and operating costs; advantages over existing comparable technologies; previous performance data; and identification of health, safety, and environmental problems.
- *Capability of the Developer*. Development of other technologies; completion of field tests; experience, credentials, and availability of key personnel; and capability to commercialize and market the technology.
- *Approach to Testing*. Operations plan; materials and equipment; range of testing; health and safety plan; monitoring plan; quality assurance plan; assignment of responsibilities; backup treatment system plan; and regulatory compliance plan.

Once the proposals are received, they are reviewed by a panel of EPA experts. Meetings are held with developers to address specific questions on their technologies. The developers of technologies that are considered acceptable are then notified.

Four solicitation cycles have been completed. These have been titled SITE-001, SITE-002, SITE-003, and SITE-004. The SITE-005 solicitation will be released in January 1990. Exhibit II-1 presents information on the 38 active technology demonstration projects for the four completed solicitation cycles.

SOLICITATION CYCLE	DATE RFP ISSUED	NUMBER OF RESPONSES RECEIVED	NUMBER OF TECHNOLOGIES SELECTED	NUMBER OF ACTIVE PROJECTS
SITE - 001	3/15/86	20	13	8
SITE - 002	1/15/87	29	11	8
SITE - 003	1/16/88	31	12	10
SITE - 004	1/6/89	24	12	12

Exhibit II-1. Selection of Demonstration Program Projects

A list of the technologies that have been accepted into the SITE Program under the four solicitations is presented in Exhibits II-2 through II-6.

Of the 38 active technologies accepted into the SITE Program during the four solicitation cycles, there are seven thermal, five biological, nine solidification/stabilization, four chemical, and thirteen physical treatment technologies in the program.

Selection of SITE-005 Demonstration Projects

Like the SITE-004 solicitation, the SITE-005 RFP was advertised in trade journals as well as the *Commerce Business Daily*. The RFP for the SITE-005 solicitation will be issued in January 1990. The fifth solicitation will focus on technologies that address: (1) the treatment of mixed, low-level radioactive wastes in soil and groundwater, (2) the treatment of soil and sludges contaminated with organics and/or inorganics, (3) materials handling as a preliminary step to treatment or further processing, (4) treatment trains designed to handle specific wastes, and (5) *in-situ* technologies, especially those providing alternatives to conventional groundwater "pump and treat" techniques.

2. Selection of Demonstration Sites

Once EPA has evaluated the technology proposals and notified the developers of their acceptance into the SITE Program, the demonstration site selection process is initiated. Potential SITE demonstration locations include federal and state Superfund removal and remedial sites, sites from other federal agencies, and developers' sites. The criteria used to screen and select candidate sites for target demonstration include the following:

- Comparability of waste with the technology
- Volume of waste
- Variability of waste
- Availability of data characterizing the waste
- Accessibility of waste
- Applicability of the technology to site cleanup goals
- Availability of required utilities (i.e., power and water sources, sewers)
- Support of community, state and local governments, and potentially responsible parties.

EPA has continued to refine the site selection process, and during FY 1989 additional procedures were implemented to expedite the technology/site matching process for SITE demonstrations. EPA is using three approaches simultaneously to facilitate the selection of sites for SITE-004 technologies:

- Discussions were held with the regions and developers regarding the type of waste needed for the demonstration during the proposal and interrogatory process. EPA has begun contacting the regions concerning the sites suggested at these meetings.
- At the same time, information is being entered into the Superfund Site Selection Support System on Superfund sites for which Records of Decision (RODs) are due in late FY 1990 and FY 1991. Data on the type of site and waste required by the SITE-004 technologies have been entered and will be matched with compatible sites. The database has allowed the identification of about 10 to 30 candidate sites for each SITE-004 technology.
- The Office of Emergency and Remedial Response, regions, and states were given the opportunity to nominate sites based on technology information provided to them in August 1989.

3. Negotiation of Cooperative Agreements

SARA authorizes the Agency to enter into grants, contracts, and cooperative agreements with technology developers. Applicants whose technologies are selected into the SITE Program through the solicitation process enter into cooperative agreements with the Agency that determine the roles and responsibilities of both parties to carry out specific projects. Usually, the developer bears the cost of locating the technology onsite, operating the equipment during the demonstration period, and demobilizing the equipment following the demonstration. EPA assists the developer with project planning and site preparation, and pays the costs associated with sampling and analysis, quality assurance and control, evaluating the data, and preparing summary reports.

Section 311(b)(5)(J) permits EPA to fund up to 50% of the developer's cost of a SITE demonstration project, if the developer shows that it cannot obtain appropriate private financing on reasonable terms and conditions sufficient to carry out the project without federal assistance. EPA can provide no more than $3 million total for any single project and no more than $10 million total in any one fiscal year for such assistance. EPA's guidelines for financial assistance were announced in January 1988 in the SITE-003 solicitation. As required by statute, developers selected for the SITE Program that desire assistance are required to demonstrate that an earnest effort has been made to obtain financing and that a financial need exists. To date, the demonstration projects have not involved funding for technology developers.

4. Community Relations Activities

A well-planned community relations effort is an integral part of the Superfund program, as well as the SITE Program. In fact, Section 311(b)(5)(E) requires the establishment of a public notice and comment period prior to the final selection of a demonstration site. The objective of this community relations program is to actively encourage two-way communication between affected communities and government agencies responsible for cleanup actions. The program enables local citizens to have input to decisions regarding demonstration activities so that the demonstration plan reflects and responds to public concerns. At the same time, the community relations program ensures that the community is provided with accurate and timely information about the demonstration and its progress. In designing a community relations program for a particular SITE demonstration, EPA focuses on the special concerns of the community. EPA has prepared and distributed site-specific technology fact sheets, and has organized public meetings for SITE demonstrations.

5. Demonstration Planning Process

After technologies and sites are selected, the next step in the process is development of a detailed technology demonstration, testing, and evaluation plan. The plan, included in the cooperative agreement between EPA and the developer, specifies all activities needed to ensure that the information objectives of the program are met. For each demonstration, the following must be addressed by the developer and EPA:

- Evaluation program duration and schedule
- Site preparation requirements
- Detailed evaluation design
- Sampling and analysis program
- Quality assurance/quality control (QA/QC) program
    - Preparation and implementation of a QA/QC Project Plan
    - QA/QC field and laboratory audits
- Health and safety requirements
    - Provisions for medical monitoring of operating and management personnel, if necessary
    - Safety training for personnel who will be in a restricted zone
    - Determination of the level of required worker protection (classification of outergarments as a function of the type of exposure)
    - Establishment of zones of safety; "clean area" establishment and movement restrictions in various zones
    - Decontamination of personnel, outergarments and equipment
    - Emergency procedures
    - Supervision responsibilities
- Demobilization of equipment.

6. Reporting Results

During Fiscal Year 1989, EPA initiated a number of actions to reduce the time for production and dissemination of demonstration results. A rigid reporting schedule has been implemented to ensure that reports on the results of the demonstrations will be available sooner. The elapsed time for report publication has been reduced by 33%. The revised SITE Program publications guidance provides for publication of the demonstration results within six months of completing the demonstration, and sets a goal for release of both the *Technology Evaluation Report* and *Applications Analysis Report* within one year from completion of the field demonstration. Early meetings between EPA and developers have helped to address and resolve issues concerning interpretation of results. An information clearinghouse for performance data on treatment technologies has also been set up and pilot tested. The clearinghouse, called the Alternative Treatment Technology Information Center (ATTIC), is a computer-based, key word searchable database that contains data and abstracts from EPA treatability studies, demonstrations, remedial actions, and state activities from over 900 technical documents and records. Interim results of the demonstrations are now available on ATTIC and OSWER's Bulletin Board shortly after preparation of the first draft of the report. EPA has also initiated a pilot test of combining the *Technology Evaluation Report* and the *Applications Analysis Report* into one report.

There are two major reports for each demonstration. The first is a technical report documenting the performance data resulting from the demonstration, and the second is a report that evaluates the applicability of the technology to other sites and wastes.

The first report, entitled the *Technology Evaluation Report*, includes testing, procedures, data collected, and QA/QC conducted. It summarizes the results in terms of performance (effectiveness and reliability) and cost. The report also addresses issues such as applicability, pre- and post-treatment requirements, and advantages/disadvantages compared with available technologies. EPA is responsible for publication and distribution of the report following review and approval.

Successful demonstration of a technology at one Superfund site does not, by itself, imply that the technology can and will be adopted for use at other Superfund sites. To enable and encourage the general use of demonstrated technologies, EPA prepares a second report that evaluates all available information on the specific technology and the applicability of each technology to other site characteristics, waste types, and waste matrices. The report, entitled the *Applications Analysis Report*, also provides cost estimates for these applications and identifies cost-controlling factors when appropriate. SITE *Applications Analysis Reports* have been published for four technologies: HAZCON, Inc., Shirco Infrared Systems, Inc. (Peak Oil and Rose Township demonstrations), American Combustion Inc., and Terra Vac, Inc.

Once results become available, the technology transfer component of the SITE Program provides technical information to potential users in a timely manner to facilitate future use of these technologies. Details on the overall approach to technology transfer in the SITE Program are presented in Section V.

7. Estimates of Technology Implementation Costs

SARA requires the SITE Program to determine whether or not each demonstrated technology is "effective and feasible." The selection of a cleanup solution involves tradeoffs among alternative criteria, including cost. Thus, SITE demonstrations must be concerned with both the engineering and economic aspects of implementing a technology. Estimating the range of each technology's implementation cost is a critical aspect of the SITE Demonstration Program. The goals of the SITE Program's cost analysis are to:

- Provide the public with both the developer's and EPA's cost estimate based on well-defined and appropriate operating scenarios.
- Identify, highlight, and analyze those key operating parameters which EPA feels are likely to have significant impacts on cost.
- Insure that the public has the ability, if necessary, to reconstruct EPA's cost analysis, recalculating the estimates by substituting assumptions more consistent with their situation. This means that all assumptions must be clearly stated and all equations clearly presented.

An economic analysis for estimating the costs (dollars per ton) is prepared for each completed SITE demonstration. The SITE *Applications Analysis Report* provides the results of this economic analysis including information on the projected costs for applying a specific treatment technology to a potential Superfund removal or remedial action, and a more comprehensive picture of the technology's potential for Superfund applications.

An estimated range of potential costs is necessary to compare the effectiveness of one technology with another. While cost alone will not be the sole criterion for accepting or rejecting any technology, relative costs will be critical. The most important part of the cost estimating process is selecting those assumptions that will serve as the basis for the final estimate. It is essential that the basis for the cost estimates is clearly stated. One approach to estimating implementation costs, which include capital, operating, and maintenance costs, would be to standardize each of the SITE cost analyses around a typical cleanup scenario. However, this is not possible due to the tremendous variability in the size and composition of Superfund sites. No economic analysis can hope to provide cost figures that take into account all of the operating parameters that ultimately impact cost, but good economic analysis insures that those assumptions that form the basis for the estimate are explicitly and clearly stated.

Implementation costs are presented in a format that offers a simple framework for presenting assumptions. Costs are partitioned into categories, each reflecting typical cleanup activities encountered on a Superfund site. This forces key assumptions within each category to be explicitly stated, particularly the variables that are highly cost-sensitive. The ultimate goal is to provide the reader with sufficient background information to allow an independent reconstruction of the estimates. Individual analysts can easily modify the assumptions and tailor the economic analysis to fit their own unique site and waste conditions. More important, readers will be able to use the framework as a tool to enhance technology comparisons.

The 12 cost categories presented below represent costs within specific activity-related groups.

- *Site Preparation Costs* -- including site design and layout, surveys and site investigations, legal searches, access rights and roads, preparations for support facilities, decontamination facilities, utility connections, and auxiliary buildings.
- *Permitting and Regulatory Costs* -- including permit(s), system monitoring requirements, and development of sampling and analytical protocols and procedures.
- *Equipment Costs* -- by subsystems, including all major equipment items such as process equipment, materials handling equipment, and residual handling equipment. Also included are design considerations such as equipment specifications, and throughput and utilization rates.
- *Startup Costs* -- including mobilization, shakedown, testing, and initiation of environmental monitoring programs.
- *Labor Costs* -- including dollars, labor rates, and level of effort for supervisory and administrative staff, professional and technical staff, maintenance personnel, and clerical support.
- *Supplies and Consumable Costs* -- including chemicals and other raw materials, maintenance materials, and expendable material (listed with quantities consumed).
- *Utilities* -- including electricity, fuel, process steam and water, and compressed air (listed with quantities consumed).
- *Effluent Treatment and Disposal Costs* -- both onsite and offsite facility costs, including air treatment, wastewater disposal and monitoring activities.
- *Residuals and Waste Shipping, Handling, and Transport Costs* -- including the preparation for shipping and actual waste disposal charges.
- *Analytical Costs* -- including laboratory analyses for operations and environmental monitoring.
- *Facility Modification, Repair, and Replacement Costs* -- including design adjustments, facility modification, scheduled maintenance, and equipment replacement.
- *Site Demobilization Costs* -- including shutdown, site cleanup and restoration, permanent storage costs, and site security.

The grouping of related cost items into logical categories facilitates the comparison of implementation costs among different technologies. While these categories encompass the typical operations associated with Superfund cleanups, they may not be applicable to all SITE technologies. Data regarding a given cost category may be unavailable, unsubstantiated, or even irrelevant. By focusing on these 12 specific categories, the analyst must make a conscious effort to note the omission of data within any one category. Thus, the reader will not be led to false conclusions and will be able to make appropriate adjustments when conducting relative cost comparisons.

The final step in estimating implementation costs for a technology is to determine effects on cost resulting from deviations from typical operating parameters. The goal is not to provide a precise cost analysis for each and every scenario, but rather to alert the reader to those conditions that experience suggests are likely to have a major impact (positive or negative) on costs.

Cost estimates for technologies in the SITE Program are discussed under each technology in the next section. Details on the assumptions that were used in preparing these cost estimates are provided in the *Applications Analysis Report* published for the relevant technology.

B. DEMONSTRATION PROGRAM PROGRESS AND ACCOMPLISHMENTS

The SITE Demonstration Program has now completed its third year of demonstrating and evaluating innovative alternative technologies that could be used to remediate uncontrolled hazardous waste sites. The major accomplishments of the SITE Demonstration Program in FY 1989 include:

- There are currently 38 technology developers, including 12 accepted in FY 1989, actively participating in the SITE Demonstration Program. They represent a wide array of innovative technologies, from thermal treatment and bioremediation to soil washing, solvent extraction, and *in-situ* stripping.
- Since 1987, EPA has conducted 14 demonstrations, including seven demonstrations completed in FY 1989.
- During FY 1989 EPA published 12 reports on eight of the demonstrated technologies.
- At least 10 field demonstrations are in the planning stages. These include *in-situ* bioremediation, plasma heat vitrification, and *in-situ* steam stripping.

The 38 technologies presently active in the SITE Program represent five process categories. There are currently seven thermal, five biological, nine solidification/stabilization, four chemical, and thirteen physical technologies in the program. The technologies and their categories are listed in Exhibits II-2 through II-6, along with a description of the status of the demonstration project.

1. Thermal Treatment Technologies

Thermal technologies use energy to destroy or decontaminate waste. These technologies can either use relatively low amounts of energy (low temperature) or high energy (high temperature) thermal processes. Low temperature thermal processes physically separate organic contamination from solid waste using elevated (300 to 700°F) temperatures. Because of the low temperatures, the organic contamination volatilized from the solid waste is not oxidized. Instead, it is burned in an afterburner or captured on a carbon bed. Low temperature thermal processes are most effective on soils contaminated with organic wastes having relatively low boiling points. Low temperature thermal treatment processes usually have lower operating costs than other thermal technologies due to lower energy requirements.

High temperature thermal treatment technologies use combustion temperatures in excess of 1650°F to destroy or detoxify hazardous wastes. Organic chemical wastes are destroyed by the high temperatures. Provided that the temperatures are high enough, any of the high temperature thermal treatment devices can detoxify most organic wastes. Solid wastes contaminated by metals can, in some cases, be detoxified with high temperature thermal treatment technologies. This occurs when the solid waste is vitrified by the high temperatures and the metals become entrapped in the glassified material.

The physical form of the waste is important in some thermal processes. For example, the Shirco Infrared Incinerator is designed to transport waste through the combustion chamber on a conveyor belt. As a result, it is limited to sludges and other non-flowing solid wastes which will not fall off of the conveyor belt.

The seven thermal technologies currently active in the SITE Program differ in the source of the energy used to achieve the necessary temperatures. Four of these processes achieve elevated temperatures through the combustion of fossil fuels (flame combustion and fluidized bed combustion). Of the three other thermal technologies, two processes use electrical resistance heating (infrared incineration), and the remaining technology uses a non-ionizing plasma torch generated by passing a gas through an electric field (plasma heat system).

The thermal treatment technologies being demonstrated under the SITE Program include four different thermal processes: flame combustion, fluidized bed combustion, infrared incineration, and plasma heat system. These thermal processing methods and the seven associated technologies are listed in Exhibit II-2 and are discussed below.

Flame Combustion

Flame combustion refers to combustion which takes place in or as the result of a hydrocarbon flame. Hydrocarbon flames result from the oxidation of hydrocarbon fuels with air, oxygen, or oxygen-enriched air. The advantage of the flame combustion process is the short residence time which allows for high waste throughput. The highly reactive environment of the flame rapidly initiates the breakdown of waste chemicals. Radiant heat transfer from the flame heats and oxidizes wastes in other parts of the combustion chamber. Hazardous wastes treated via flame combustion are readily converted to carbon dioxide and water. In flame combustion, temperatures vary dramatically in different layers of the flame area (oxidation zone). The process may only be able to break down the surface layer of large particles passing through the oxidation zone. Two of the seven thermal processes in the SITE Program utilize flame combustion.

American Combustion, Inc.

Technology Description. The PYRETRON^R oxygen-air-fuel burner, developed by American Combustion, Inc., of Norcross, Georgia, uses oxygen-enriched air to burn natural gas at higher temperatures. Oxygen, in combination with air and natural gas, is combusted in the PYRETRON^R burner. Heat released from the combustion is used to destroy solid hazardous waste fed separately into the burner. The PYRETRON^R burner is designed to fit onto any conventional combustion unit for burning liquids, soils, and sludges. By replacing some of the combustion air with oxygen, the PYRETRON^R is more efficient. Using less air is advantageous because the nitrogen in air takes away heat, puts a greater load on the air pollution control equipment, and requires a longer retention time in the combustor before the waste is fully incinerated. The higher temperatures also ensure more complete incineration of the wastes, thereby increasing the destruction and removal efficiency and reducing stack gas emissions. The rate of waste throughput is also increased, thus reducing unit costs. Burner operation is computer controlled to automatically adjust the amount of oxygen according to sudden changes in key process parameters. Solid wastes contaminated with hazardous organics are suitable for the PYRETRON^R technology. In general, the technology is applicable to any waste that can be incinerated.

Demonstration Status. The PYRETRON^R was demonstrated at EPA's Combustion Research Facility (CRF) in Jefferson, Arkansas from November 1987 to January 1988. The primary objective of the demonstration was to compare the performance of the PYRETRON^R with a conventional air-based incineration system. For this demonstration, the conventional air burner of the CRF rotary kiln system was substituted with the PYRETRON^R oxygen burner. Eight comparison tests were conducted using a mixture of 60% decanter tank tar sludge from coking operations (RCRA listed waste K087) and 40% contaminated soil from the Stringfellow Acid Pit Superfund site in California. Stringfellow is a Superfund site that was used as a dump for industrial wastes from World War II to the early 1980s. Soils on the site are contaminated with waste acids containing organics and metals. Six polynuclear aromatic hydrocarbon compounds were selected as the principal organic hazardous constituents (POHCs) for the test program--naphthalene, acenaphthylene, fluorene, phenanthrene, anthracene, and fluoranthene.

For the conventional system, the optimum feed rate was 105 lbs/hour. During testing of the PYRETRON^R, the mass charge size was maintained at 21 lbs. However, the throughput rate was doubled over air-only operation by reducing the charge interval from 12 to 6 minutes. This resulted in a throughput increase

EXHIBIT II-2. STATUS OF THERMAL TREATMENT TECHNOLOGIES IN THE SITE PROGRAM

	DEVELOPER	TECHNOLOGY	LOCATION OF DEMONSTRATION	STATUS	Technology Selected	Site Selected	Demonstration Plan Completed	Cooperative Agreement Application	Demonstration Completed	Technology Evaluation Report Available	Applications Analysis Report Available
Flame Combustion	1. American Combustion, Inc. Norcross, GA	Pyretron Oxygen Burner	Combustion Research Facility (CRF) Jefferson, AR (Region 6)	The Technology Evaluation Report was available in April 1989 and the Applications Analysis Report was available in October 1989.	●	●	●	●	●	●	●
	2. Horsehead Resources Development Co., Inc. Monaca, PA	Flame Reactor	Horsehead Facility Monaca, PA (Region 3)	Efforts are underway to identify a suitable demonstration site. Waste will be brought onto the Monaca site.	●						
Fluidized Bed	3. American Toxic Disposal, Inc. Wilmette, IL	Vaporization Extraction System	None identified	Efforts are underway to identify a suitable demonstration site.	●						
	4. Ogden Environmental Services, Inc. San Diego, CA	Circulating-Bed Combustor (CBC)	La Jolla, CA (Region 9)	The demonstration was conducted in March 1989 using a pilot-scale CBC.	●	●	●	●	●		
Infrared Incineration	5. Shirco Infrared Systems, Inc. Dallas, TX	Electric Infrared Incinerator	Peak Oil Superfund Site Brandon, FL (Region 4)	The Technology Evaluation Report was available in September 1988. The Applications Analysis Report published in June 1989 contained the results of both the Peak Oil and Rose Township demonstrations.	●	●	●	●	●	●	●
	6. Shirco Infrared Systems, Inc. Dallas, TX	Electric Infrared Incinerator (Pilot-Scale)	Rose Township Demode Road Superfund Site Rose Township, MI (Region 5)	The Technology Evaluation Report was available in April 1989.	●	●	●	●	●	●	
Plasma System	7. Retech, Inc. Ukiah, CA	Plasma Heat	Montana Pole/ Silver Bow Creek Superfund Sites Butte, MT (Region 8)	The demonstration is planned for 1990.	●	●		●			

Withdrawn Technologies	Waste-Tech Services, Inc. Golden, CO	Fluidized Bed Combuster (Fluidized Bed)	None selected	Withdrew from the program in July 1987 due to indemnification issues.
	Westinghouse Electric Corporation Madison, PA	Electric Pyrolyzer (Pyrolysis)	Westinghouse Facility Waltz Mill, PA (Region 3)	Removed from the program on September 7, 1988. Status will remain unchanged unless Westinghouse meets the following two conditions: 1) successful completion of DOE test and 2) demonstration of the readiness of the technology.
	New York State Department of Environmental Conservation Albany, NY	Plasma Arc (Plasma System)	Love Canal, NY (Region 2)	Withdrew from the program in May 1988 due to contractual issues with the developer.
	Westinghouse Electric Corporation Madison, PA	Pyroplasma System (Plasma System)	Westinghouse Facility Waltz Mill, PA (Region 3)	Removed from active participation on October 12, 1989 due to permitting problems and difficulty in identifying a suitable waste for the unit.

from 105 lbs/hour to 210 lbs/hour. Incinerator operation was fully satisfactory under both modes of operation. Performance remained satisfactory even when the mass charge size was increased to 34 lbs. The results of the demonstration are summarized below:

- The PYRETRON^R burner achieved greater than 99.99% destruction and removal efficiencies (DRE) of all POHCs measured in all test runs performed.
- The PYRETRON^R burner with oxygen enhancement achieved double the waste throughput possible with conventional incineration.
- All particulate emission levels in the scrubber system discharge were significantly below the hazardous waste incinerator performance standard of 180 mg/dscm at 7% oxygen.
- Solid and liquid residues were contaminant free.
- There were no significant differences in transient carbon monoxide level emissions between air-only incineration and PYRETRON^R oxygen enhanced operation.
- Costs savings can be achieved in many situations.

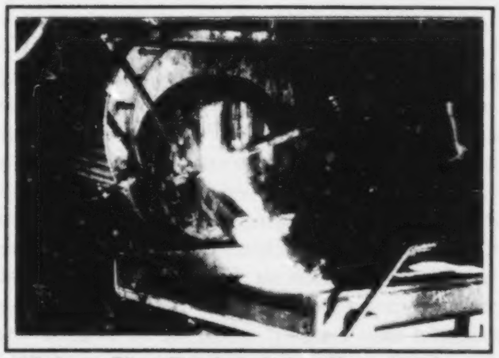
Applications Analysis. The PYRETRON^R system can be used to treat any waste amenable to treatment by conventional incineration, but it is not suitable for processing RCRA heavy metal wastes or inorganic wastes. The field evaluations conducted under the SITE Demonstration Program yielded the following conclusions:

- The PYRETRON^R burner system is a viable technology for treating Superfund wastes.
- The system is capable of doubling the capacity of a conventional rotary kiln incinerator. This increase is more significant for wastes with low heating values. Throughput increases for wastes with moderate heating value are also possible by use of water injection to help dissipate heat. For wastes with high heating value, throughput will eventually be limited by the incinerator's ability to dissipate heat.
- In situations where particulate carryover resulting from excessive gas volume causes operational problems, the PYRETRON^R system may increase reliability. The PYRETRON^R system reduces combustion gas volume by replacing some of the combustion air with oxygen.
- Use of the PYRETRON^R can result in elevated NO_x emissions which should be monitored.

Because of the throughput increases, the PYRETRON^R system can make hazardous waste incineration more economical in situations in which the throughput increases are large, the operating and fuel costs are high, and oxygen costs are relatively low. Since the PYRETRON^R is a burner system and therefore only a part of an incineration system, the capital costs associated with the PYRETRON^R system are expected to be small relative to the costs of the entire incinerator. Operating and utility costs per ton of waste processed are expected to be reduced most by use of the PYRETRON^R in situations in which throughput increases are readily achievable. The economic analysis showed a representative cost savings of approximately $30 per ton. Savings will depend on site-specific conditions, such as the heating value of the waste, the scale of operation, and the location. Little additional data exist beyond the SITE demonstration and tests at EPA's Air and Energy Engineering Research Laboratory.

Horsehead Resources Development Co., Inc.

Technology Description. The Flame (slagging) Reactor developed by Horsehead Resources Development Co., Inc., of Monaca, Pennsylvania, is a patented, hydrocarbon-fueled, flash smelting system that can treat solids, soils, and sludges containing volatile heavy metals. The reactor processes wastes with a very hot (greater than 3632°F) reducing gas which



Moltan Slag Produced by Horsehead Resources Development Co.'s Flash Smelting System

is produced from the combustion of solid or gaseous hydrocarbon fuels in oxygen-enriched air. Typically, the system is operated to produce a decontaminated molten slag (a glasslike solid when cooled) and a recyclable, heavy metal-enriched oxide. The overall volume reduction achieved (of waste to slag) depends on the chemical and physical properties of the waste. Electric arc furnace dust, lead blast furnace slag, iron residues, zinc plant leach residues and purification residues, and brass mill dusts and fumes have been successfully treated. Metal bearing wastes previously treated contained zinc (up to 40%), lead (up to 10%), cadmium (up to 3%), chromium (up to 3%), as well as copper, cobalt, nickel, and arsenic. The Flame Reactor demonstration plant at Monaca, Pennsylvania, has a capacity of 1.5 to 3.0 tons/hour, and has been used commercially to recover metals from electric arc furnace dust.

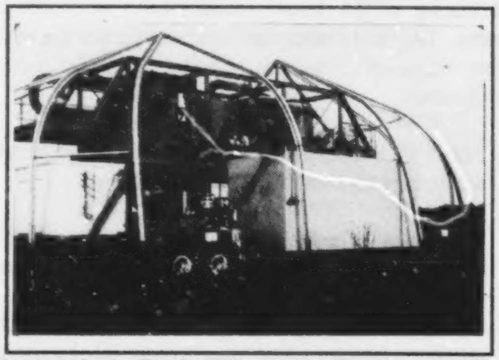
Demonstration Status. EPA is working closely with Horsehead Resources Development Co., Inc. to identify a suitable demonstration site. Waste from a Superfund site will be brought to the developer's facility in Monaca, Pennsylvania, for testing.

Fluidized Bed Combustion

Fluidized bed combustors are used to incinerate halogenated and nonhalogenated solids, sludges, slurries, and liquids in a controlled atmosphere with surplus oxygen levels. These systems are also used to destroy polychlorinated biphenyls (PCBs) and phenolic wastes and to thermally decontaminate soils. In this process a hot fluidized bed of inert granular material (usually sand) is used to transfer heat to the waste streams to be incinerated. Fluidization is achieved by passing heated pressurized combustion air upward through the sand bed, keeping the bed in suspension. In order to maintain the solid waste in the fluidized mode, the waste needs to be prescreened for size. Waste is normally injected within or just above the bed. Combustion takes place as the waste contacts the hot fluidized bed. Ash will normally exit the fluid bed reactor airborne in the flue gas. The advantages of the fluidized bed design are the relatively low excess air requirements, good mixing between air and fuel, and energy efficiency derived from the ability to heat the fluidization air from the stack gas. This process requires a long residence time and much lower throughput than flame combustion. Fluidized beds require frequent attention for maintenance and for cleaning of the bed. Two of the seven thermal processes in the SITE Program utilize fluidized bed combustion.

American Toxic Disposal, Inc.

Technology Description. American Toxic Disposal, Inc., of Wilmette, Illinois, has developed the Vaporization Extraction System (VES), a low-temperature fluidized bed method for removing organic and volatile inorganic compounds from soils, sediments, and sludges. Contaminated materials are mixed with hot gas (at about 320°F) in a co-current, stirred fluidized bed. Direct contact between the waste material and the hot gas forces water and the contaminants into the gas stream, which flows out of the dryer to a gas treatment system. The gas treatment system, consisting of a cyclone separator, baghouse, venturi scrubber, plate scrubber, and chiller unit, removes dust and organic vapors from the gas stream. Treatment residuals consist of: (1) 96% to 98% of the solid waste feed as clean, dry dust; (2) a small quantity of pasty sludge containing organics; (3) a small quantity of spent adsorbent carbon; (4) wastewater that may need further treatment; and (5) small quantities of baghouse and cyclone dust. The technology can remove volatile and semivolatile organics, including PCBs, polynuclear aromatic hydrocarbons (PAHs), and pentachlorophenol (PCP), volatile inorganics, and some pesticides from soil, sludge, and sediment. In general, the process treats waste containing less than 5% total organic contaminants and 30% to 90% solids. Nonvolatile inorganic contaminants (such as metals) in the waste feed do not inhibit the process, but are not treated.



American Toxic Disposal's Transportable Vaporization Extraction System

Demonstration Status. The VES to be demonstrated is a transportable, pilot-scale system on five trailers, which treats about 8.5 tons of waste per hour. The process has been previously tested on PCB contaminated sediments. The mobile unit is fully assembled and is currently located in Honey Creek, Wisconsin. The developer will conduct shakedown/

optimization tests using uncontaminated soil excavated from a nearby site as part of system mobilization for the SITE demonstration. The developer is seeking a site containing organics-contaminated river or harbor sediments, and a suitable demonstration site has not yet been identified. PCBs are of particular interest, and sandy soils may also be acceptable. The demonstration test objectives are to evaluate feed handling, decontamination of solids, and treatment of gases generated by the process.

Ogden Environmental Services, Inc.

Technology Description. A Circulating Bed Combustor (CBC), developed by Ogden Environmental Services, Inc., of San Diego, California, destroys a variety of waste materials at relatively low temperatures (approximately 1600°F). The unit employs simultaneous limestone injection, which neutralizes acid gases and eliminates the need for a scrubber. Waste material and limestone are fed into a combustion chamber along with recirculating bed material from a hot cyclone. The materials travel at a high speed through the combustion chamber to the cyclone, where solids are separated from the hot gases. The hot gases pass through a convective cooler and baghouse filter before being released to the atmosphere. The treated ash is transported out of the system by an ash conveyor for proper disposal. The unit may be used to recover heat as steam or to produce electricity or hot water.

This technology may be applicable to hydrocarbon wastes, soils and lagoons containing hazardous and nonhazardous wastes, oily sludges, and munitions and chemical agents. It may be capable of treating feedstock contaminated with PCBs, PCPs, halogenated wastes, chlorinated sludges, aniline still-bottoms, and oily and solvents sludges, among others. It has also been applied, during trial tests, to wastes such as carbon tetrachloride, freon, malathion, trichloroethylene, dichlorobenzene, aromatic nitrate, and PCBs. The CBC technology developed by Ogden is one of only seven incinerators permitted to burn PCBs in the U.S.

Demonstration Status. The demonstration was conducted in March 1989 using a two million Btu/hour pilot-scale CBC which processed approximately 5,500 lbs of high-sulfur acidic petroleum refinery waste from the McColl Superfund site in Fullerton, California. The McColl site was used for the disposal of petroleum refinery waste in the 1940s. Overall, the pilot-scale unit performed reliably during the pilot test. Carbon tetrachloride was used as the performance indicator, and the CBC met the 99.99% DRE limit established by RCRA for trial burns. Hydrochloric acid emissions and flue gas particulates were well below the RCRA limits, although further testing is needed to ensure compliance of flue gas particulates with local air standards. No significant concentrations of hazardous organics or metals were detected in the flue gas. Carbon monoxide, nitric oxides, and total hydrocarbon emissions were within the facility permit conditions; however, sulfur dioxide results were not quantifiable because of malfunction of the measuring equipment. Lastly, organics originally present in the waste feed were not detected in the fly ash and bed ash streams, and PCBs, dioxins, and furans also were not detected.

Infrared Incineration

Infrared incinerators use silicon carbide elements to generate intense thermal radiation. Other thermal processes use turbulent air flows. In this process, materials to be treated pass through the combustion chamber on a conveyor belt and are exposed to the radiation. This reduces the amount of the ash in the air stream since, without turbulent air flows, the ashes fall from the belt to the ash collector. Wastes are limited to sludges and other non-flowing solid organic wastes which will not fall off the conveyor belt. Wastes should be screened so that large particles do not interfere with belt operation. Off-gases pass into a secondary chamber (usually an afterburner) for further infrared irradiation and increased retention time. Flue gases are treated based on feed constituents and are emitted, as are ash and any scrubber effluents. Infrared incineration provides an airtight operation which allows the thermal destruction of low-level radioactive materials. Two of the seven thermal processes in the SITE Program utilize infrared incineration--the pilot- and full-scale infrared systems developed by Shirco Infrared Systems, Inc.

Shirco Infrared Systems, Inc.

Technology Description. The electric infrared incineration technology, developed by Shirco Infrared Systems, Inc., of Dallas, Texas, is a mobile thermal processing system that uses electrically-powered silicon-carbide rods to heat organic wastes to combustion temperatures. Any remaining organics are incinerated in an afterburner. Waste is fed into the primary chamber on a wire-mesh conveyor belt and is exposed to infrared radiant heat (up to 1850°F). A gas-fired secondary combustion chamber destroys gaseous volatiles from the primary furnace. Off-gas is treated by an emission control system before being released to the atmosphere. The commercial unit is transportable and allows for discontinuous operation. This technology is suitable for soils or sediments containing organic contaminants. Liquid organic wastes can be treated after mixing with sand or soil.

Demonstration Status. Demonstration of the electric furnace was carried out at full scale at the Peak Oil Superfund site, Brandon, Florida, in August 1987. As part of the removal operation by EPA, a nominal 100-ton per day Shirco Infrared System treated nearly 7,000 cubic yards of waste oil sludge containing PCBs and lead. During the SITE demonstration, the system was evaluated to determine its reliability of PCB destruction and if the solubility of lead compounds could be reduced. A second SITE demonstration of the system, at pilot-scale, took place at the Rose Township Demode Road Superfund site, Rose Township, Michigan, in November 1987. The pilot-scale system was evaluated for effectiveness in removing and destroying organic contaminants and reducing the mobility of metal contaminants under both standard and varied operating conditions. The results of both demonstrations were similar and are summarized below:

- In both tests, at standard operating conditions, PCBs were reduced to less than 1 ppm in the ash, with a DRE greater than 99.99% (based on detection limits).

- In the pilot-scale demonstration, the RCRA standard for particulate emissions (180 mg/dscf) was achieved. In the full-scale demonstration, however, this standard was not met in all runs due to scrubber inefficiencies.

- The mobility of the lead was not reduced.

- The pilot-scale unit demonstrated satisfactory performance with high feed rate and reduced power consumption when fuel oil was added to the waste feed and the primary chamber temperature was reduced.

Applications Analysis. In addition to the SITE demonstrations at the Peak Oil and Demode Road sites, information is available on the Shirco technology performance from the pilot-scale tests and commercial cleanups performed by 10 different organizations, including two full-scale applications at Superfund sites besides Peak Oil. These range from the conduct of pilot-scale tests to obtain TSCA permits, to incineration of thousands of tons of PCB-contaminated soil. Recent commercial operations have experienced on-line reliability factors from 24% to 61%. Intermittent operations of commercial units over one to three month periods have reported utilization factors up to 90%. Data evaluated during the applications analysis suggest that additional preprocessing may be needed to meet suitable ranges for various waste characteristics. The applications analysis is summarized below:

- The infrared incineration process is capable of meeting both RCRA and TSCA DRE requirements for air emissions. Operations on waste feed contaminated with PCBs have consistently met the TSCA guidance level of 2 ppm in ash.

- Improvements in the scrubber system resulted in compliance with RCRA and TSCA particulate emission standards.

- Based on recent commercial operations, projected utilization factors range from 50% to 75%.

- Economic analysis based on the demonstrations and other field data suggest a cost range from $180/ton to $240/ton of waste feed, excluding waste excavation, feed preparation, and ash disposal costs.

Plasma System

Plasma heat processes decontaminate waste by contacting it with a gas which has been energized into its plasma state by an electrical discharge. The electrical discharge is created across two oppositely charged electrodes. Both electrodes can reside within the plasma torch itself (a non-transferred torch), or one electrode can be contained within the torch while the waste can serve as the other (ground) electrode (a transferred torch). Plasmas contain very high energy. Waste organic chemicals injected directly into a plasma plume are efficiently fragmented and converted to carbon dioxide and water. Solid waste heated by plasma can be vitrified. The advantages of vitrification over other thermal processes are the lack of oxidation products and large air emissions and the reduced leachability of inorganic materials such as heavy metals. One of the seven thermal processes in the SITE Program utilizes a plasma heat system.

Retech, Inc.

Technology Description. Retech, Inc., of Ukiah, California, has developed a thermal treatment centrifugal reactor that uses plasma heat to treat soils and sludges contaminated with organics and metals. The solid components are melted (vitrified) and cast or granulated for disposal, while the volatile compounds are decomposed by the heat generated by the plasma. Liquid and solid wastes can be treated by this technology.

Demonstration Status. EPA is conducting a demonstration of Retech's pilot system in coordination with the Department of Energy (DOE), Idaho National Engineering Laboratory (INEL). Retech's pilot system has been installed at the DOE (INEL) research facility in Butte, Montana. Preparations are underway for testing by both EPA and DOE. The unit will be tested on waste from the Montana Pole and Silver Bow Creek Superfund sites near Butte, which were contaminated by mining and wood treating operations. The demonstration is planned for 1990.

Withdrawn Thermal Treatment Technologies

In July 1987, Waste-Tech Services, Inc., withdrew its fluidized bed combustor from the SITE Program due to liability issues. In May 1988, the New York State Department of Environmental Conservation withdrew its plasma arc technology from the SITE Program because New York State cancelled its plans to develop this technology for use at Love Canal. In September 1988, Westinghouse Electric Corporation was removed from the SITE Program because their pyrolyzer technology was not ready for a field demonstration. In October 1989, Westinghouse Electric Corporation was notified that their pyroplasma system was removed from the SITE Program because of permitting problems and difficulty in identifying a suitable waste for the unit.

2. Biological Treatment Technologies

Biological treatment processes use the enzymatic activities of naturally occurring microorganisms, bacteria and fungi, to transform or destroy hazardous waste compounds found in liquids, sludges, or contaminated soils. Compounds that could possibly be treated in this manner include aliphatics, aromatics, and chlorinated aromatic organic compounds. Bioremediation has been successfully demonstrated on aqueous wastes and only recently has been tried on soils and debris. Biological processes are sensitive to environmental conditions, such as pH, temperature, oxygen concentration, concentrations of nutrients necessary for their growth, and concentrations of inhibitory levels of certain heavy metals. These factors are altered in order to optimize the biodegradation activities of the microorganisms. Biological treatment of many groundwater contaminants can significantly minimize the treatment costs associated with the most common treatment process for these materials--excavation, transport, and incineration. Biological treatment offers the potential of decomposing many hazardous wastes to nontoxic substances resulting in a permanent solution to the removal and disposal of such materials.

The biological treatment processes that are presently being demonstrated under the SITE Program involve aerobic biodegradation. The five biological treatment technologies are listed in Exhibit II-3 and are discussed below.

Aerobic Biodegradation

Aerobic biodegradation involves the treatment of contaminated soil or sludge in a large mobile bioreactor. An aqueous slurry is created and then is mechanically agitated in a reactor vessel to keep the solids suspended and maintain the appropriate environmental conditions. Inorganic and organic nutrients, oxygen, and acid or alkali for pH control may be added to maintain optimum conditions. Microorganisms may be added initially to seed the bioreactor or added continually to maintain the correct concentration of biomass. Once biodegradation of the contaminants is completed, residual water may require further treatment prior to disposal, and emissions may be released to the atmosphere or treated prior to release. Some of the advantages of using a bioreactor include:

- Greater process management and control
- Increased contact between microorganisms and contaminants
- Use of specific cultures or inoculum
- Decreased acclimation times and faster biodegradation rates.

One disadvantage is the additional excavation and handling of the contaminated material that is often required.

These processes can also be applied to contaminated subsurface soil without excavation by directly applying nutrients and oxygen into the contaminated soil. After nutrients and oxygen (if required) are added, significant reduction in contaminant concentrations may take quite a while. In addition, the microorganisms are sensitive

EXHIBIT II-3. STATUS OF BIOLOGICAL TREATMENT TECHNOLOGIES IN THE SITE PROGRAM

	DEVELOPER	TECHNOLOGY	LOCATION OF DEMONSTRATION	STATUS	Technology Selected	Site Selected	Demonstration Plan Completed	Cooperative Agreement Application	Demonstration Completed	Technology Evaluation Report Available	Applications Analysis Report Available
Aerobic Biodegradation	8. BioTrol, Inc. Chaska, MN	Fixed-Film Biodegradation	MacGillis &Gibbs Superfund Site New Brighton, MN (Region 5)	A pilot-scale unit was demonstrated from July 24 through September 1, 1989.	●	●	●	●	●		
	9. DETOX, Inc. Dayton, OH	Fixed-Film Biological Treatment	G & H Landfill Utica, MI (Region 5)	A tentative site has been selected. Sampling for the treatability tests has been conducted. If the site is acceptable, the demonstration will be scheduled for summer 1990.	●	●					
	10. ECOVA Corporation Redmond, WA	*In-Situ* Bioremediation	Goose Farm Superfund Site Plumstead Township, NJ (Region 2)	A preliminary biotreatability study was completed in July 1989. Field sampling for site characterization and a treatability study will be completed in fall/winter 1989. The demonstration is planned for spring 1990.	●	●					
	11. MoTec, Inc. (a division of Remediation Technologies, Inc.) Austin, TX	Liquid-Solid Contact Digestion	None selected	A wood-preserving site is under review for the demonstration.	●						
	12. Zimpro/Passavant, Inc. Rothschild, WI	Powered Activated Carbon Treatment (PACT)	Syncon Resins Superfund Site Kearney, NJ (Region 2)	A draft demonstration plan has been completed. A three month demonstration is scheduled for early 1990.	●	●		●			

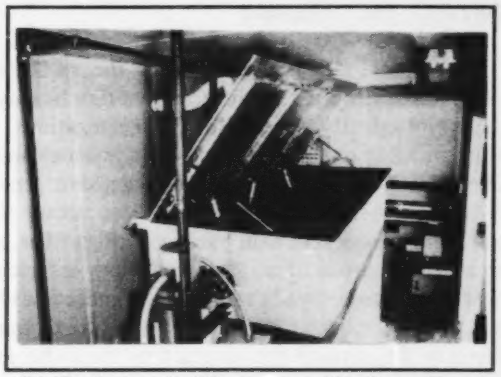
Withdrawn Technologies	Air Products and Chemicals, Inc. Allentown, PA	Fluidized Bed Biological System (Aerobic Biodegradation)	None selected	Withdrew from the program on September 20, 1988 due to indemnification and site selection issues.
	DETOX Industries, Inc. Sugarland, TX	Aerobic Biodegradation	United Creosote Superfund Site Conroe, TX (Region 6)	Removed from the program on January 10, 1989 due to failure to perform laboratory treatability tests.

to substrate conditions. Slight changes in those conditions can reduce the degradation rate or kill the microorganisms. Four of the five biological treatment technologies in the SITE Program involve aerobic biodegradation.

The biological treatment technologies include: (1) *in-situ* biodegradation in the soil without excavation by directly supplying nutrients and oxygen into the contaminated soil; (2) treatment of slurries of soil and associated contaminant organic compounds that adhere to the clay and fine particles of the soil in a liquid-solid bioreactor tank; and (3) treatment of contaminated groundwater or water from lagoons by pumping the contaminated liquids through fixed-film aerobic bioreactors. One of the processes involves treatment of contaminated waters in an activated sludge treatment plant which utilizes aerobic microorganisms to break down organic contaminants in aqueous waste streams. These microorganisms metabolize biodegradable organics. The aeration process includes pumping the waste to an aeration tank where the biological treatment occurs. Following this, the stream is sent to a clarifier where the liquid effluent (treated aqueous waste) is separated from the sludge biomass. Typically this process is used only for waste streams where less than 1% of the total volume is contaminants.

BioTrol, Inc.

Technology Description. BioTrol, Inc., of Chaska, Minnesota, has developed a system for treatment of toxic organics in wastewater streams, referred to as the BioTrol Aqueous Treatment System (BATS). During this process, contaminated water enters a tank where the pH is adjusted and inorganic nutrients are added. The water then flows to the reactor where the contaminants are biodegraded. The microorganisms which perform the degradation are immobilized in a three cell, submerged fixed-film bioreactor. Each cell is filled with a highly porous packing material to which the microbes adhere. The degradation is accomplished primarily by indigenous microorganisms; however, the system can be amended with specific microorganisms with special metabolic capabilities. For example, a bioreactor treating a waste stream containing PCP--a compound normally resistant to microbial degradation--can be amended with an organism with specific capability to degrade PCP. As the water flows through the bioreactor, the contaminants are degraded completely to carbon dioxide, water, and chloride ion.



BioTrol, Inc.'s Bioreactor Used to Treat Wastewater

This technology is mainly applicable to aqueous streams contaminated with organic compounds, such as PCP and creosote (wood treatment compounds) and other hydrocarbons. The technology can be used to remove certain inorganic compounds (such as nitrates); however, it cannot remove metals. Other potential target waste streams include chlorinated hydrocarbons, coal tar residues, and organic pesticides. The BATS is being evaluated for applicability to underground storage tank contaminants, such as fuels and solvents.

The system is primarily applicable to treatment of groundwater; however, treatment of process and lagoon waters has also been demonstrated. BioTrol has built a mobile system with a nominal capacity of 5 gallons/minute. The bioreactor and all ancillary equipment are mounted in an enclosed trailer.

Demonstration Status. From July 24 through September 1, 1989, BioTrol, Inc., demonstrated a pilot-scale biological treatment system for organics in wastewater at the MacGillis & Gibbs Superfund site in New Brighton, Minnesota, an operating wood treating facility. The system was used to treat groundwater principally contaminated with PCP at concentrations up to 50 ppm.

During the six-week test, the unit operated 24 hours/day, seven days/week at a varied flow rate (1, 3, and 5 gallons/minute), for each two-week period. A total of about 176,000 gallons of groundwater was treated. EPA sampled influent, biomass, off-gases, and effluent. The unit operated well during the test. Treated water was discharged to the sewer under a local permit after carbon treatment.

DETOX, Inc. (Dayton)

Technology Description. DETOX, Inc., of Dayton, Ohio, has developed a submerged fixed-film bioreactor that biologically treats low concentrations of biodegradable organic compounds in aqueous waste. The DETOX system consists of an above ground fixed-film reactor, supplemental nutrient storage tank and pump, sump tank with pump, cartridge filter, and an activated carbon filter. This technology is typically used to treat groundwater and industrial process waters, but is also applicable to lagoon and/or pond waters. Some of the contaminants targeted by the technology are benzene, toluene, xylene, alcohols, and ketones.

Demonstration Status. Treatability tests are being conducted at the G&H Landfill Superfund site in Utica, Michigan. The site contains groundwater contaminated with low levels of organics, primarily xylene and methylene chloride. If this site is selected, the demonstration of the DETOX system is expected to start in summer 1990.

ECOVA Corporation

Technology Description. ECOVA Corporation of Redmond, Washington, has designed a bioremediation technology to aerobically biodegrade chlorinated solvents and nonchlorinated organic compounds. The technology can be applied in two configurations: *in-situ* biotreatment of soil and water, and onsite bioreactor treatment of contaminated groundwater. The ECOVA process adds oxygen and nutrients through a system of wells and trenches to accelerate bioremediation. Pumping and recharge wells circulate groundwater through the zone of contamination, becoming in effect a very large packed bed biological processing plant similar to those used in above ground treatment. The system pulls offsite groundwater back onsite until offsite concentrations are below 100 ppb. Percolation wells recharge water pumped from the recovery system and treat suspected source areas onsite. The *in-situ* bioremediation process involves enhancing the microbial degradation of contaminants in subsurface soils and groundwater without excavation of overlying soil. The technology uses special strains of cultured bacteria and microorganisms naturally occurring in onsite soils and groundwater. The end products are carbon dioxide, water, and bacterial biomass. Contaminated groundwater can also be recovered and treated in an above ground bioreactor. This process can be applied to water, soil, sludge, sediment, and other types of materials contaminated with organic compounds.

Demonstration Status. The demonstration is planned for spring 1990 at the Goose Farm Superfund site in Plumstead Township, New Jersey. Groundwater at the site contains a wide range of toxic organic compounds. During the demonstration, water, nutrients, and microorganisms will be pumped into the saturated zone through a recharge well to enhance bioremediation below ground. Groundwater collected at an extraction well downgradient of the contaminant plume will be treated in the above ground reactor. Two monitoring wells will be placed between the recharge and the extraction well. Water samples collected from the recovery well, the two monitoring wells, and the bioreactor, will be analyzed to determine changes in compound concentrations.

MoTec, Inc.

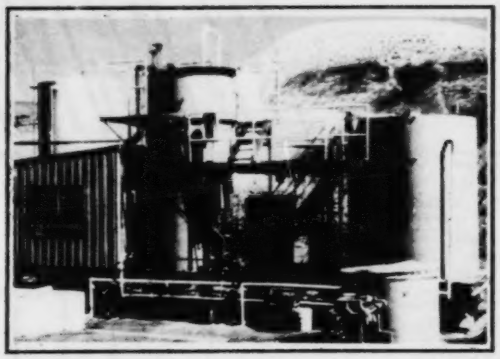
Technology Description. MoTec, Inc., a division of Remediation Technologies, Inc., of Austin, Texas, has developed a method of organic waste biodegradation called the Liquid-Solid Contact Digestion process (LSCD). An aqueous slurry is created and then is mechanically agitated in a reactor vessel to keep the solids suspended and maintain the appropriate environmental conditions. Inorganic and organic nutrients, oxygen, and acid or alkali for pH control may be added to maintain optimum conditions. Microorganisms may be added to the bioreactor to enhance the activity associated with the contaminated soil. The supplemental cultures may be added initially to seed the bioreactor or may be added periodically if the microbes do not continue to grow in the bioreactor.

During this process, sludges or soils contaminated with organic compounds are first mixed with water and emulsifiers. The waste then undergoes aerobic biological treatment in a batch digester and is transferred to a polishing cell for final treatment. Following the completion of the process, the supernatant from the polishing tank is recycled to the primary contact tank, and the sludge is treated by soil tillage or reactors onsite. This technology is applicable for treating halogenated and nonhalogenated organic compounds and some pesticides. However, it is not suitable for treating wastes containing high levels of inorganic contaminants unless a suitable pretreatment step is included to remove the toxic levels of the metals present.

Demonstration Status. A wood-preserving site is currently under investigation for the demonstration.

Zimpro/Passavant, Inc.

Technology Description. The process used by Zimpro/Passavant, Inc., of Rothschild, Wisconsin, is a variation of the activated sludge process. The modified activated sludge process developed by Zimpro/Passavant, Inc. combines a biological treatment (activated sludge) with powdered activated carbon treatment in one step called the PACT^R process and wet air oxidation (WAO) of the waste sludges as the total treatment of the contaminated aqueous waste. Enhancement of the activated sludge treatment allows Zimpro/Passavant's PACT^R process to treat aqueous waste streams which contain contaminants at higher concentrations than 1% of the waste stream.



Zimpro/Passavant, Inc.'s Trailer-Mounted PACT^R Unit

Demonstration Status. A three-month demonstration of Zimpro/Passavant's biological treatment unit operating at 42,000 gallons/day at the Syncon Resins Superfund site in Kearny, New Jersey, is planned for early 1990. The process will treat about 500,000 gallons of groundwater at the site. The contaminated groundwater contains volatile organic compounds, including toluene and xylene, and some semivolatile organic contaminants.

Withdrawn Biological Treatment Technologies

Air Products and Chemicals, Inc., withdrew from the SITE Program in September 1988, due to liability and indemnification issues. In January 1989, DETOX Industries, Inc., was removed from the SITE Program because of their failure to perform laboratory treatability tests.

3. Solidification/Stabilization Treatment Technologies

Solidification/stabilization treatment processes immobilize the toxic and hazardous constituents in the waste. This can be done by changing the constituents into immobile (insoluble) forms, binding them in an immobile, insoluble matrix and/or binding them in a matrix which minimizes the material surface exposed to solvent leaching. Often the immobilized product has structural strength sufficient to help protect itself from future fracturing, thereby preventing increased leaching. Most of the binding agents used in these processes are proprietary.

Solidification/stabilization processes have two key components: the chemical reactants and the mixing equipment. The chemicals typically include portland cement, lime, fly ash, clay, silicates, and a proprietary chemical. The proprietary chemical is supposed to react with the metals and organics to form insoluble compounds and to prevent the organic constituents from interfering with the pozzolanic (cement) reactions. Effective mixing is required whether the waste and the chemicals are mixed *in-situ* or above ground in tanks, drums, or pits. Without thorough mixing, the chemicals cannot immobilize the hazardous constituents. The SITE demonstrations have included an evaluation of the mixing on treatment effectiveness.

The solidification/stabilization treatment processes being demonstrated under the SITE Program include: cement-based fixation, pozzolanic-based fixation, and vitrification. These processes and the nine associated technologies are listed in Exhibit II-4 and are discussed below.

Cement-Based Fixation

The cement-based fixation process treats sludges and soils containing metal cations, radioactive wastes, and solid organic wastes (i.e., plastics, resins, tars) by the addition of large amounts of siliceous materials combined with cement to form a dewatered stabilized, solidified product. Soluble silicates are added to accelerate hardening and contaminant containment. Larger amounts of dissolved sulfate salts or metallic anions, such as arsenate and borates, will hamper solidification. Organic matter, lignite, silt, or clay in the wastes will increase setting time. Four of the nine solidification/stabilization technologies in the SITE Program involve cement-based fixation processes.

EXHIBIT II-4. STATUS OF SOLIDIFICATION /STABILIZATION TREATMENT TECHNOLOGIES IN THE SITE PROGRAM

	DEVELOPER	TECHNOLOGY	LOCATION OF DEMONSTRATION	STATUS	Technology Selected	Site Selected	Demonstration Plan Completed	Cooperative Agreement Application	Demonstration Completed	Technology Evaluation Report Available	Applications Analysis Report Available
Cement-Based Fixation	13. Chemfix Technologies, Inc. Metairie, LA	Chemical Fixation/Stabilization	Portable Equipment Salvage Co. Site Clackamas, OR (Region 10)	The demonstration occurred on March 6-17, 1989. The Technology Evaluation Report and the Applications Analysis Report will be combined into one report as a pilot project. The report will be available in spring 1990.	●	●	●	●	●		
	14. International Waste Technologies/Geo-Con, Inc. Wichita, KS	*In-Situ* Soil Stabilization	G.E. Facility Hialeah, FL (Region 4)	The Technology Evaluation Report was published in June 1989. The Applications Analysis Report will be available in early 1990.	●	●	●	●	●	●	
	15. Silicate Technology Corporation Scottsdale, AZ	Silicate-Based Solidification	Kaiser Steel Resources Fontana, CA (Region 9)	Treatability study samples were collected in July 1989. A draft demonstration plan has been prepared. The demonstration is planned for 1990.	●	●	●				
	16. S.M.W. Seiko Redwood City, CA	*In-Situ* Soil Mixing	None selected	Three candidate sites have been identified and are under review.	●						
Pozzolanic-Based Fixation	17. HAZCON, Inc. Katy, TX	Solidification/ Stabilization	Douglassville Superfund Site Reading, PA (Region 3)	The Technology Evaluation Report and the Applications Analysis Report were published in May 1989.	●	●	●	●	●	●	●
	18. Separation and Recovery Systems, Inc. Irvine, CA	Solidification/ Stabilization	None identified	Efforts to identify a suitable demonstration site are underway.	●						
	19. Soliditech, Inc. Houston, TX	Solidification/ Stabilization	Imperial Oil/Champion Chemical Co. Superfund Site Morganville, NJ (Region 2)	The Technology Evaluation Report was available in late 1989. The Applications Analysis Report will be available in early 1990.	●	●	●	●	●	●	
	20. Wastech, Inc. Oak Ridge, TN	Solidification/ Stabilization	None identified	Efforts to identify a suitable demonstration site are underway.	●						
Vitrification	21. Geosafe Corporation Kirkland, WA	*In-Situ* Vitrification	None identified	Efforts to identify a suitable demonstration site are underway.	●						

Withdrawn Technologies	Waste Chem Corporation Paramus, NJ	Volume Reduction Solidification (Asphalt-Based Microencapsulation)	Woodland Route 532 Site Woodland Township, NJ (Region 2)	Withdrew from the program in October 1988 due to its inability to compete economically with other available technologies.

Chemfix Technologies, Inc.

Technology Description. Chemfix Technologies, Inc., of Metairie, Louisiana, has developed a proprietary process (CHEMFIX) that stabilizes high-molecular-weight organic and inorganic constituents in waste slurries. This fixation/stabilization process uses proprietary reagent additives, such as soluble silicates and silicate setting agents. The products of the process are intended to be stable, friable materials with good erosion resistance and low permeabilities. The process is designed as a continuous operation capable of rapidly treating (up to 100 tons/hour) large quantities of soils, sludges, and wastewaters without creating a large increase in volume of the treatment material. This technology is suitable for base, neutral, or acid extractable organics of high molecular weight, such as refinery wastes, creosote, and wood-treating wastes.

Chemfix Technologies, Inc.'s Solidification/Stabilization Process

After the contaminated material is excavated and screened to remove pieces larger than one inch, a conveyor belt moves it from the feed hopper to the weight feeder, where it is measured. The homogenizer mixes the wastes with water to achieve the desired moisture content. The wetted material then moves to a Chemfix-designed pug mill, where it is blended with the proprietary reagents. After the material is thoroughly mixed, it is discharged and allowed to harden. The final product is a solidified mass.

Demonstration Status. The demonstration was conducted in March 1989 on waste from four areas of the Portable Equipment Salvage Company (PESC) site in Clackamas, Oregon. The PESC site operated as a transformer and metals salvage facility from the early 1960s until 1985. Waste from the site contained primarily lead, copper, and PCBs. The demonstration involved evaluation of the full-scale processing unit with a capacity of 100 tons/hour. The demonstration included a long-term testing program designed to determine the effects of aging on the strength, acid neutralization capacity, and leaching potential of the treated wastes. The tests will be conducted every six months for a period of five years following the demonstration.

Preliminary results from the demonstration indicate that:

- The Chemfix technology was effective in reducing the concentrations of lead and copper in the extracts from the Toxicity Characteristic Leaching Procedure (TCLP). The concentrations in the extracts from the treated wastes were 94% to 99% less than those from the untreated wastes. Total lead concentrations in the raw waste approached 14%.

- The volume increase in the excavated waste material as a result of treatment varied from 20% to 50%.

- The results of the tests for durability were very good. The treated wastes showed little or no weight loss after 12 cycles of wetting and drying or freezing and thawing.

- The unconfined compressive strength (UCS) of the wastes varied between 27 and 307 psi after 28 days. Permeability decreased more than one order of magnitude.

- The air monitoring data suggest that there was no significant volatilization of PCBs during the treatment process.

It is anticipated that a single report, combining the *Technology Evaluation Report* and the *Applications Analysis Report*, will be available in spring 1990.

International Waste Technologies/Geo-Con, Inc.

Technology Description. International Waste Technologies (IWT)/Geo-Con, Inc., of Wichita, Kansas, developed the ***In-Situ*** Soil Stabilization System, which immobilizes organic and inorganic compounds in wet or dry soils, using reagents (additives) to produce a cement-like mass. This process employs a proprietary binding agent for use with cement and a specific soil mixing technology which precludes the need for soil excavation. A hollow stem auger developed by Geo-Con injects the chemicals into the soil. The auger has both cutting and mixing blades with two internal conduits which allow for injection of the additive slurry and supplemental water. Additive injection is on the downstroke, with further mixing upon auger withdrawal. Treated soil columns are 36 inches in diameter and are positioned to provide an overlapping pattern. The result is a soil with a dense, homogeneous, low porosity, structure. The IWT/Geo-Con technology can be applied to soils, sediments, and sludge-pond bottoms contaminated with organic compounds and metals. The technology has been laboratory-tested on soils containing PCBs, PCPs, refinery wastes, and chlorinated and nitrated hydrocarbons.

Demonstration Status. During April 1988, International Waste Technologies and Geo-Con, Inc., demonstrated their *in-situ* stabilization/solidification process at the site of a General Electric Corporation electric service shop in Hialeah, Florida. Approximately 13,000 square feet of ground was contaminated with PCBs and lead at this site. Geo-Con's Deep Soil Mixing (DSM) System was used to drill and blend waste material with IWT's patented bonding agent. The major objectives of the demonstration were to: (1) evaluate the ability of the process to immobilize PCBs in the soil, (2) determine the level of performance and reliability of the mechanical equipment being used, (3) assess the effectiveness of the process for land stabilization, and (4) observe the integrity of the solidified soil over a period of five years.

Two 10x20-foot test sectors contaminated with PCBs and lead were treated to a depth of 18 feet. One localized area also contained volatile organics and heavy metals. The ratio of additive to soil was approximately 1 to 7. A single auger unit was tested during the demonstration, although a four-auger unit is typically used for remediation. Long-term monitoring tests were performed on the treated sectors ten months after completion of the demonstration. Results from the SITE demonstration indicate that:

- Based on TCLP leachate analysis, the process appears to immobilize PCBs. However, because PCBs did not leach from most of the untreated soil samples, the immobilization of PCBs in the treated soil could not be confirmed.
- Sufficient data were not available to evaluate the performance of the system with regard to metals or other organic compounds.
- The bulk density of the soil increased 21% after treatment. This increased the volume of treated soil by 8.5% and caused a small ground rise of one inch per treated foot of soil.
- The permeability of the treated soil was satisfactory, decreasing by four orders of magnitude compared to the untreated soil.
- The Geo-Con DSM equipment operated reliably.

Applications Analysis. The *Applications Analysis Report* will be available in early 1990. The results are summarized below:

- Microstructural analyses of the treated soils indicated a potential for long-term durability. High UCSs and low permeabilities were recorded.
- Data provided by IWT indicate some immobilization of volatile and semivolatile organics. However, this may be due to organophilic clays present in the IWT reagent. There are insufficient data to confirm this immobilization.
- Performance data are limited outside of the SITE demonstration. The developer modifies the binding agent for different wastes. Treatability studies should be performed for specific wastes.
- The process is economical: $194 per ton for the 1-auger machine used in the demonstration; $110 per ton for a commercial 4-auger operation.

Silicate Technology Corporation

Technology Description. Silicate Technology Corporation (STC), of Scottsdale, Arizona, has developed a method to stabilize metals and high-molecular-weight organics in soils and sludges.

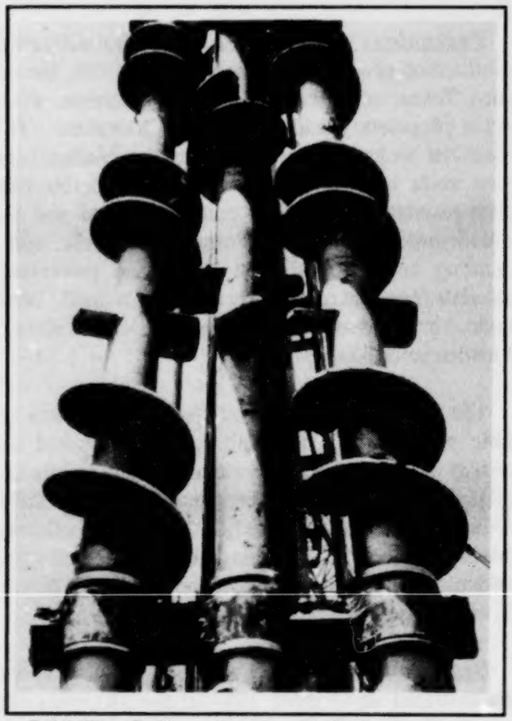
This solidification/stabilization technology uses silicate compounds and can be used as two separate technologies--one that fixes and solidifies organics and inorganics contained in contaminated soils and sludges, and another that removes organics from contaminated water. For soils and sludges, a proprietary reagent, FMS silicate, selectively adsorbs organic contaminants before the waste is mixed with a cement-like material to form a high-strength, non-leaching cement block (monolith). The process can use standard debris screening and mixing equipment (such as cement trucks). For water, the same reagent (FMS silicate) is used in conjunction with granular activated carbon to remove organics from groundwater. The resulting waste material is then solidified by the first technology. The Silicate Technology solidification/stabilization process has already been used at hazardous waste sites.

According to Silicate Technology, their process may be used to treat the following contaminants in unlimited concentrations: metals, cyanides, fluorides, arsenates, and ammonia, and other organics as well as higher weight organics, such as halogenated, aromatic, and aliphatic compounds.

Demonstration Status. After the two principal responsible parties for the Tacoma Tar Pits site refused to approve the use of this site, a new site was tentatively selected in Fontana, California. The site owner, Kaiser Steel Resources, has expressed an interest in hosting a SITE demonstration of the STC combined technology. A draft plan for collecting samples and conducting treatability studies was prepared and samples were collected in July 1989. A draft demonstration plan has been prepared for the Kaiser site. The major concern is the delay which may result if a RD&D permit is required for this project. The demonstration is planned for 1990.

S.M.W. Seiko, Inc.

Technology Description. S.M.W. Seiko, Inc., of Redwood City, California, has developed the Soil-Cement Mixing Wall (SMW) technique for *in-situ* treatment of contaminated soil. The process uses multi-axis, overlapping hollow-stem augers to inject and blend treatment additives, such as solidification/stabilization agents. The system can treat 90 to 140 cubic yards *in-situ* per eight-hour shift at depths of up to 100 feet. Two to three augers, each up to three feet in diameter, are mounted on a crawler-type base machine. This technique has been used for more than 18 years on various construction applications including cutoff walls and soil stabilization. This technology is applicable to soils contaminated with metals and semivolatile organic compounds.



S.M.W. Seiko, Inc.'s Soil-Cement Mixing Augers

Demonstration Status. Several potential demonstration sites have been identified and are under review. For the demonstration, S.M.W. Seiko will use commercially available solidification/stabilization agents to treat contaminated soils, resulting in a monolithic block down to the treatment depth.

Pozzolanic-Based Fixation

The pozzolanic-based fixation process treats sludges and soils containing heavy metals, waste oils, solvents, and low-level radioactive wastes, onsite by the addition of large amounts of pozzolanic materials (fly ash, lime) combined with cement to form a dewatered stabilized, solidified product. Materials, such as borates, sulfates, and carbohydrates, interfere with the process. Four of the nine solidification/stabilization techniques in the SITE Program involve pozzolanic-based fixation processes.

HAZCON, Inc.

Technology Description. The solidification/stabilization process developed by HAZCON, Inc., of Katy, Texas, mixes hazardous wastes, cement, water, and a proprietary additive called Chloranan. This treatment technology immobilizes the contaminants from soils by binding them into a concrete-like, leach-resistant mass. The unit consists of soil and cement holding bins, a Chloranan feed tank, and a blending auger to mix the waste and pozzolanic materials (portland cement, fly ash, or kiln dust). Water is added as necessary, and the resultant slurry is allowed to harden before disposal.

The process utilizes a mobile field blending unit (10 cubic yards/hour). The unit is truck-mounted and consists of a blending auger which mixes contaminated soil or sludge, cement, binding agent, and water. Other mixing units can also be used for large waste volumes. This technology is suitable for soils and sludges contaminated with organic compounds, heavy metals, oil, and grease.

Demonstration Status. The HAZCON process was demonstrated in October 1987 at the Douglassville Superfund site (a former oil reprocessing plant), near Reading, Pennsylvania. The contaminated soil wastes at the Douglassville site came from six sources--one each from two large lagoons once filled with waste oil sludges and subsequently drained and backfilled with soil; an oily filter cake disposal area; an oil drum storage area; an oil reprocessing area; and a waste land farm. Oil and grease levels varied from 1% to 25%. Wastes contained volatile and semivolatile organics, PCBs, and heavy metals. Cement was used at approximately a 1:1 ratio with waste. Samples were taken from the untreated waste, the blended (treated) slurry after seven days of curing, and core samples from the 28-day-old blocks. The samples were analyzed for soil characteristics, leachability, permeability, UCS, microstructure changes, and contaminant levels. Long-term sampling of solidified waste will be conducted for five years following the demonstration.

Results of the SITE demonstration indicate the following:

- The physical characteristics of the treated wastes were very good. The UCS of the solidified waste ranged from about 220-1570 psi. Short-term durability test results were also very good, but the microstructural analysis seemed to indicate possible sample degradation in the future. Permeabilities of the solidified waste were very low, in the range of 10^{-8} to 10^{-9} cm/sec (considered excellent). There was a large increase in the volume of the solidified waste to approximately double that of the waste feed.

- Stabilization of metals in the waste was successful, with reductions of metal leachate concentrations greater than a factor of 100. Even with high concentrations of organics that interfere with the stabilization process, the metals were effectively treated. According to test procedures, the solidified mass was subjected to a grinding process prior to leach tests; there was little change in leaching concentrations of organics (volatile, semivolatile, and oil and grease) before and after treatment.

Applications Analysis. The applications analysis results are summarized below:

- The HAZCON process can solidify contaminated material with high concentrations (up to 25%) of organics. However, organic contaminants, including volatiles and base/neutral extractables, were not immobilized to any significant extent.

- Heavy metals are immobilized. In many instances, leachate reductions were greater than 100 fold.

- The physical properties of the treated waste exhibit high UCSs, low permeabilities, and good weathering properties.

- Treated soils undergo volumetric increases.

- The process is economical, with costs expected to range between approximately $97 and $206 per ton not including waste excavation and disposal of solidified blocks.

Results from seven case studies other than the SITE demonstration were presented in the *Applications Analysis Report*.

Separation and Recovery Systems, Inc.

Technology Description. Separation and Recovery Systems, Inc., of Irvine, California, has developed a limestone-based solidification/stabilization process. In this process, sludge is removed from the waste pit and mixed with lime in a separate blending pit. The fixation reactions occur over a 20-minute period and are exothermic. The temperature of the material in the blending pit rises for a very brief time to around 414°F, and some steam is evolved. After 20 minutes, almost all of the material has been fixed. The reactions are completed over the next few days. The fixed material is stored in a product pile until the waste pit has been cleaned, and then the product is returned to the pit and compacted. Permeabilities of the solidified waste are expected to be low, around 10^{-10} cm/sec, and the volume of the waste should only be increased by 30%. This process uses conventional earth moving equipment and is, therefore, highly mobile. This technology should be applicable to acidic sludges containing at least 5% hydrocarbons. It should also stabilize waste containing up to 80% organics.

Demonstration Status. EPA is working closely with Separation and Recovery Systems to locate a suitable site for the demonstration of this technology.

Soliditech, Inc.

Technology Description. Soliditech, Inc., of Houston, Texas, has developed a solidification and stabilization process to chemically and physically immobilize hazardous constituents contained in slurries. During the process, the proprietary reagent URRICHEM is dispersed throughout the waste in order to achieve complete blending of all ingredients (waste, pozzolan, aqueous phase, and other additives). The multiphase cementation process immobilizes hazardous compounds by cross-linking organic and inorganic particles, coating large particles, and sealing small pores and spaces. This sealing process significantly reduces leaching potential. The Soliditech technology is suitable for treating soils and sludges contaminated with organic compounds, metals, inorganic compounds, and oil and grease.

Solidified Waste from Soliditech, Inc.'s Solidification/Stabilization Process

Demonstration Status. The demonstration of the Soliditech process was conducted in December 1988 at the Imperial Oil Company/Champion Chemical Company Superfund site, a former oil reclamation and chemical processing facility in Morganville, New Jersey. Three sources of waste were utilized at the site--oil and grease contaminated soils, used filter-cake material, and an oily sludge from an unused storage tank. Two to six cubic yards of material from each of the three sources were processed through Soliditech's mobile mixing unit. Contaminants from the site included PCBs, heavy metals, petroleum hydrocarbons, and low levels of volatile organics. Evaluation of the solidified waste will continue over the next three to five years.

Samples were analyzed to determine a wide range of physical and chemical characteristics--they were subjected to several leaching tests, and evaluated for strength and durability. Evaluation of the demonstration results indicated the following:

- Chemical analyses of extracts and leachates showed that heavy metals present in the untreated waste were immobilized.
- The process solidified both solid and liquid wastes with high organic content (up to 17%) as well as oil and grease.
- Physical test results of the solidified waste samples showed: (1) UCSs ranged from 390 to 860 psi, (2) very little weight loss after 12 cycles of wet/dry and freeze/thaw durability tests, (3) low permeability of the treated waste, and (4) increased density after treatment.
- The solidified waste increased in volume by an average of 22%. The bulk density of the waste material increased by approximately 35% due to solidification.

- Semivolatile organic compounds (phenols) were detected in the treated waste and the TCLP extracts from the treated waste, but not in the untreated waste or its TCLP extracts. The presence of these compounds is believed to result from chemical reactions in the waste treatment mixture.

- Oil and grease content of the untreated waste ranged form 2.8% to 17.3% (28,000 to 173,000 ppm). Oil and grease content of the TCLP extracts of the solidified waste ranged from 2.4 to 12 ppm.

- The pH of the solidified waste ranged from 11.7 to 12.0. The pH of the untreated wastes ranged from 3.4 to 7.9.

- Visual observation of the solidified waste showed dark inclusions approximately 1 mm in diameter. Ongoing microstructural studies are expected to confirm that these inclusions are encapsulated wastes.

Wastech, Inc.

Technology Description. Wastech, Inc., of Oak Ridge, Tennessee, has developed a solidification/stabilization process that uses proprietary surfactants (detergents) to segregate organic pollutants into micelles before mixing the waste with proprietary bonding agents and pozzolanic and cementatious material. This technology can be applied to soil, sludge, and liquid wastes containing inorganic and volatile or semivolatile organic contaminants. Organics present in low-level radioactive waste may also be effectively treated to facilitate disposal. The materials handling system consists of standard equipment, such as a pug mill mixer cement truck, a cement batcher, and a cement pump. The treated material is monolithic and can be solidified into blocks or cured as a single monolith.

Demonstration Status. EPA is in the process of selecting a site for the Wastech technology demonstration. Efforts are also directed at locating several sites from which suitable treatability samples could be obtained. Treatability studies are currently underway on two wastes--an oily waste and a wood preserving waste. A third study is proposed for a mixed waste.

Vitrification

Vitrification is a process that uses very high temperatures to convert hazardous wastes into a glassy substance. The process is carried out by inserting large electrodes into contaminated soils containing significant levels of silicates. Graphite on the surface connects the electrodes to the soil. A high current of electricity passes through the electrodes and graphite. The heat causes a melt that gradually works downward through the soil. Some contaminant organics are volatilized and escape from the soil surface and must be collected by a vacuum system. Inorganics and some organics are trapped in the melt, which as it cools becomes a form of obsidian or very strong glass. When the melt is cooled, it forms a stable noncrystalline solid. One of the nine solidification/stabilization technologies in the SITE Program is a vitrification process.

Geosafe Corporation

Technology Description. Geosafe Corporation, of Kirkland, Washington, will demonstrate a technology developed by Battelle Pacific Northwest Laboratory. The technology is an *in-situ* vitrification (ISV) process that destroys organic pollutants in soils and sludges by pyrolysis and inorganic pollutants are immobilized within the vitrified mass. Both the airborne organic and inorganic combustion byproducts are collected in a negatively pressurized hood which draws the contaminants into an off-gas treatment system that removes particulates and other pollutants of concern. The basic configuration of the ISV process consists of an electrical network with four electrodes driven/pushed into or placed in drilled holes in the soil or sludge, a capture hood to collect fumes or gases from the setting and direct it to an off-gas treatment system, and the off-gas treatment system itself.

Demonstration Status. This process has been demonstrated at full-scale on radioactive wastes at the Department of Energy's Hanford Nuclear Reservation. Pilot tests have been performed on PCB wastes, industrial lime sludge, dioxins, metal plating wastes, and other solid combustibles and liquid chemicals. EPA is working closely with Geosafe to identify a suitable demonstration site.

Withdrawn Solidification/Stabilization Treatment Technologies

In October 1988, Waste Chem Corporation withdrew from the SITE Program due to its inability to compete economically with other available technologies.

4. Chemical Treatment Technologies

Chemical treatment processes are those in which a chemical reaction is used to alter or destroy a hazardous waste component. The hazardous waste molecule may be slightly changed by the chemical reaction, so that it is less toxic or more amenable to other treatment techniques, or it may be completely destroyed and rendered harmless. Chemical treatment techniques are applicable to both organic and inorganic wastes, and may be formulated to address specific target compounds in a mixed waste. Some heating and physical energy requirements may be necessary to support the chemical reactions, but the reactions themselves are responsible for the treatment as opposed to thermal processes which provide for destruction of organic molecules solely by addition of heat. One limiting factor is that impurities and mixed waste components may interfere with the process chemical reaction and impact the treatment efficiency or produce hazardous byproducts.

The four chemical treatment technologies being demonstrated under the SITE Program are listed in Exhibit II-5 and are discussed below.

Oxidation-Reduction

The chemical oxidation-reduction process is employed to destroy hazardous components or convert the hazardous components of the waste stream to less hazardous forms. The process is based on oxidation-reduction reactions between the waste components and added reactants in which the oxidation state of one reactant is raised while that of another is lowered. This chemical treatment process consists of initial pH adjustment, addition of reagents, mixing, and treatment to remove or precipitate the reduced or oxidized products. The applicable oxidation processes include hydrogen peroxide oxidation, ozonation, alkaline chlorination, hypochlorite chlorination, electrolytic oxidation, and chemical dechlorination. This process is applicable to liquids and sludges containing organic and inorganic compounds. The composition of the waste must be known to prevent the inadvertent production of a more toxic or more hazardous end product. All four of the chemical treatment technologies in the SITE Program are oxidation-reduction processes.

EXXON Chemical Company/Rio Linda Chemical Company, Inc.

Technology Description. EXXON Chemical Company of Long Beach, California, in cooperation with Rio Linda Chemical Company, Inc., of Sacramento, California, has developed a chemical oxidation technique that uses chlorine dioxide to oxidize organic pollutants in aqueous streams to non-toxic organic acids and salts. The system generates the chlorine dioxide, at least 95% pure, onsite to minimize the hazards associated with its transportation and storage. The chlorine dioxide reagent is described by the developer as an aggressive oxidizer that does not form chlorinated compounds. Wastes that may be treated by this technology include bacteria, many simple organics, and pesticides in aqueous solutions. Systems processing up to 250 gallons/minute are used commercially in the petroleum industry to destroy organic pollutants and biomass in wastewater.

Demonstration Status. Efforts to identify a demonstration site are underway. The demonstration requires an aqueous waste containing organics other than chlorinated aliphatics.

EXXON Chemical Company/Rio Linda Chemical Company, Inc.

Technology Description. In a second project, EXXON Chemical Company and Rio Linda Chemical Company, Inc., will use chlorine dioxide to oxidize simple and complex cyanide pollutants found in aqueous waste, sludge, and soil to chloride and cyanate ions. The process has been used to treat wastes with cyanide concentrations of up to 500 ppm.

Demonstration Status. Efforts are underway to identify a demonstration site. This second project will be a separate demonstration using the same process described above, but will concentrate on destruction of simple and complex cyanides. A site contaminated with cyanides is needed for the demonstration.

EXHIBIT II-5. STATUS OF CHEMICAL TREATMENT TECHNOLOGIES IN THE SITE PROGRAM

	DEVELOPER	TECHNOLOGY	LOCATION OF DEMONSTRATION	STATUS	Technology Selected	Site Selected	Demonstration Plan Completed	Cooperative Agreement Application	Demonstration Completed	Technology Evaluation Report Available	Applications Analysis Report Available
Oxidation-Reduction	22. EXXON Chemical Company/ Rio Linda Chemical Company, Inc. Long Beach, CA	Chemical Oxidation of Organics	None identified	Efforts to identify a demonstration site are underway.	●						
	23. EXXON Chemical Company/ Rio Linda Chemical Company, Inc. Long Beach, CA	Chemical Oxidation of Cyanide	None identified	Efforts to identify a demonstration site are underway.	●						
	24. QUAD Environmental Technologies Corporation Northbrook, IL	Chemical Scrubbing System	None identified	Efforts to idenfify a demonstration site are underway	●						
	25. Ultrox International, Inc. Santa Ana, CA	Ultraviolet Radiation and Ozone Treatment	Lorentz Barrel and Drum Superfund Site San Jose, CA (Region 9)	The demonstration was conducted between Feburary 17 and March 10, 1989. The Technology Evaluation Report and the Applications Analysis Report will be available in spring 1990.	●	●	●	●	●		

QUAD Environmental Technologies Corporation

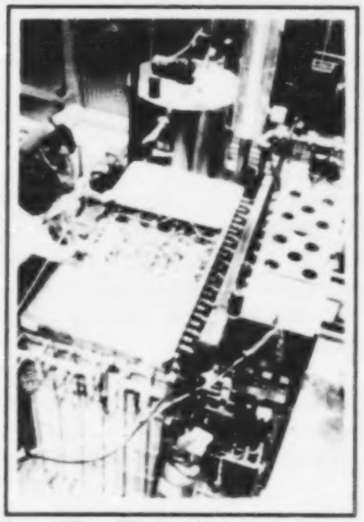
Technology Description. QUAD Environmental Technologies Corporation, of Northbrook, Illinois, has developed QUAD Chemtact™, a patented technology used to treat contaminants, such as organics, in gaseous waste streams through efficient gas-liquid contacting. It is based on generating droplets of controlled chemical solution (sodium hypochlorite) with a gaseous waste stream. The system has been used for over 14 years in various municipal and industrial applications for wastes contaminated with hydrogen sulfide and various organics. Two mobile units are used--a two-stage 800 cubic feet/minute system and a one-stage 2,500 cubic feet/minute system. This technology can be used on gaseous waste streams containing a wide variety of organic or inorganic contaminants, but is best suited for volatile organic compounds.

Demonstration Status. Efforts are underway to identify a site containing organics emitted in the air stream. The technology will be demonstrated in conjunction with a treatment process, such as vacuum extraction or air stripping, that creates a contaminated gaseous exhaust.

Ultrox International, Inc.

Technology Description. Ultrox International, Inc., of Santa Ana, California, has developed its Ultraviolet Radiation and Oxidation System to oxidize organic compounds found in groundwater. The ULTROX^R process uses a combination of ultraviolet light radiation, ozone, and hydrogen peroxide to oxidize organic compounds in water. The final products of the reaction are salts, water, carbon dioxide, and possibly some organic degradation products. The reactor is the center of the process, where UV radiation and oxidants are brought into close contact with contaminated water. The approximate UV intensity, ozone, and hydrogen peroxide doses are determined from pilot-scale studies. The high reaction rate and treatment efficiency are attributed to the direct photolysis of certain organics by the UV light and the generation of hydroxyl radicals which have a high oxidation potential. The system has been developed and used to destroy explosives, pesticides, volatile organic compounds (VOCs), PCBs, and other organic compounds in wastewater and groundwater.

The treatment system includes four skid-mounted modules--UV radiation/oxidation reactor module, ozone generator module, hydrogen peroxide feed system, and catalytic ozone decomposer (Decompozon) unit for treating reactor off-gas.



Top Pilot Plant View of Ultrox International, Inc.'s Ultraviolet Radiation and Oxidation System

Demonstration Status. The demonstration of the ULTROX^R process was conducted at the Lorentz Barrel and Drum Superfund site in San Jose, California, over a two-week period in February and March 1989. Approximately 13,000 gallons of groundwater contaminated with VOCs from the site were treated in the ULTROX^R system by the commercial-size reactor during 13 test runs. During the first 11 runs, five operating parameters were adjusted to evaluate the system: hydraulic retention time, oxidant dose, hydrogen peroxide dose, UV lamp intensity, and influent pH level. The last two runs were conducted to verify the reproducibility of the system's performance, with the system operating at the optimal conditions determined from the first 11 runs.

Out of 44 VOC samples, three were chosen to be used as indicator parameters. The results of the SITE demonstration are summarized below:

- Removal efficiencies for trichloroethylene (TCE) were about 99%. Removal efficiencies for 1,1 dichloroethane (1,1-DCA) and 1,1,1-trichloroethane (1,1,1-TCA) were about 58% and 85%, respectively. Removal efficiencies for total VOCs were about 90%.

- For some compounds, removal from the water phase was due to both chemical oxidation and stripping. Stripping accounted for 12% to 75% of the total removal for 1,1,1-TCA and 5% to 44% for 1,1-DCA. Stripping was less than 10% for TCE and vinyl chloride, and was negligible for other VOCs present.

- The Decompozon unit reduced ozone to less than 0.1 ppm (OSHA standards), with efficiencies greater than 99.99%. VOCs present in the air within the treatment system, at approximately 0.1 to 0.5 ppm, were not detected after passing through the Decompozon unit.

- Very low total organic carbon removal was found, implying that partial oxidation of organics occurred with complete conversion to carbon dioxide and water.

5. Physical Treatment Technologies

Physical treatment processes separate the waste stream by either applying physical force or changing the physical form of the waste. Various physical processes, such as adsorption, distillation, or filtration, can be utilized to separate waste streams. Physical treatment is applicable to a wide variety of liquid and solid wastes, but further treatment, such as incineration, is usually required. Some of the resulting residues can be recycled.

The physical treatment processes to be demonstrated under the SITE Program include: evaporation and steam stripping, filtration, freezing crystallization, and solvent extraction. These processes and the 13 associated technologies are listed in Exhibit II-6 and are discussed below.

Evaporation and Steam Stripping

Evaporation is the physical separation of a liquid from a dissolved or suspended solid by the application of energy to volatilize the liquid. Volatile organic compounds can be removed from a contaminated area by phase changes. This can be achieved by speeding the vaporization process which releases the volatile compounds into the carrier gas stream for removal and detoxification. Since vaporization is the function of the partial pressure of these volatile compounds, the speed of vaporization can be increased by raising the temperature (hot air or steam injection) or reducing the atmospheric pressure (vacuum extraction). In hazardous waste treatment, evaporation may be used to isolate the hazardous material in one of the two phases, simplifying subsequent treatment.

The operation of steam stripping uses steam to evaporate volatile organics from aqueous wastes. Steam stripping is essentially a continuous fractional distillation process carried out in a packed or tray tower. Clean steam provides direct heat to the column in which gas flows from the bottom to the top of the tower. The resultant residuals are contaminated steam condensate, recovered solvent, and stripped effluent. Since steam stripping is a totally enclosed system, there are no air contaminants released to the atmosphere. Five of the 13 physical treatment technologies in the SITE Program involve evaporation and steam stripping processes.

AWD Technologies, Inc.

Technology Description. AWD Technologies, Inc., of San Francisco, California, uses an integrated *in-situ* vapor extraction and steam stripping process to remove VOCs from contaminated soil and groundwater. The system combines the AquaDetox steam stripping tower, developed and patented by the Dow Chemical Company, to separate organics from water, and an *in-situ* soil vapor extraction/reinjection process (SVE System) developed by Woodward-Clyde Consultants. The two processes form a closed-loop system that provides simultaneous *in-situ* remediation of contaminated groundwater and soil with no air emissions.

The AquaDetox system strips VOCs from feedwater (such as extracted groundwater) with steam under vacuum. The steam-organic vapors are condensed, and the resulting aqueous and organic phases are separated for reuse or disposal.

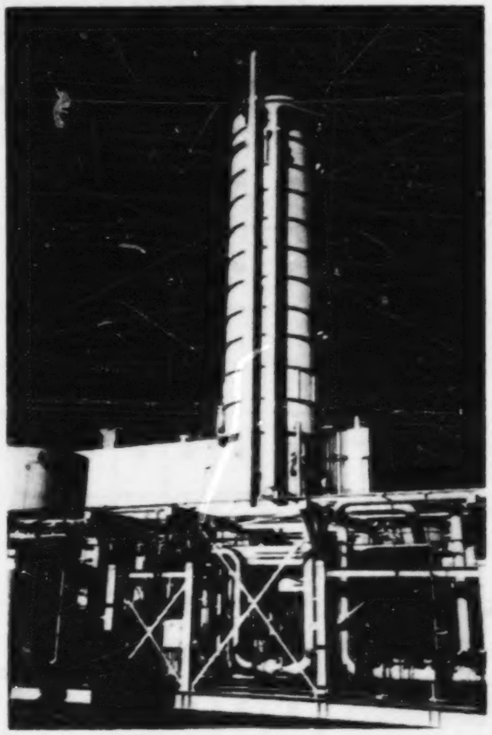
The SVE process applies a vacuum to VOC-contaminated soil, thereby inducing a flow of air through the soil and removing vapor phase VOCs with the extracted soil gas. The soil gas is then treated by the AquaDetox system. A granulated activated carbon (GAC) unit treats noncondensable vapor from both the

EXHIBIT II-6. STATUS OF PHYSICAL TREATMENT TECHNOLOGIES IN THE SITE PROGRAM

	DEVELOPER	TECHNOLOGY	LOCATION OF DEMONSTRATION	STATUS	Technology Selected	Site Selected	Demonstration Plan Completed	Cooperative Agreement Application	Demonstration Completed	Technology Evaluation Report Available	Applications Analysis Report Available
Evaporation and Steam Stripping	26. AWD Technologies, Inc. San Francisco, CA	*In-Situ* Vapor Extraction	San Fernando Valley Superfund Site Burbank, CA (Region 9)	The full-scale system has been in operation as part of the cleanup of this site since September 1988. The demonstration is planned for spring 1990.	●	●					
	27. Chemical Waste Management, Inc. Riverdale, IL	Rotary Thermal Desorber	Kettleman Hills, CA site (Region 9)	A TSCA permit application has been submitted to the Office of Toxic Substances. The demonstration is planned for spring 1990.	●	●		●			
	28. Solvent Services, Inc. San Jose, CA	*In-Situ* Steam Injection and Vacuum Extraction	Solvent Services, Inc. Superfund Site San Jose, CA (Region 9)	The six-month demonstration is planned for 1990.	●	●		●			
	29. Terra Vac, Inc. Dorado, PR	*In-Situ* Vacuum Extraction	Valley Manufacturing Groveland Wells Superfund Site Groveland, MA (Region 1)	The Technology Evaluation Report was published in April 1989. The Applications Analysis Report was published in July 1989.	●	●	●	●	●	●	●
	30. Toxic Treatments (USA), Inc. San Mateo, CA	*In-Situ* Steam/Air Stripping	Annex Terminal Site San Pedro, CA (Region 9)	A full-scale prototype was demonstrated in September 1989. Preliminary test data should be available in spring 1990.	●	●	●	●	●		
Filtration	31. E.I. DuPont de Nemours, Inc., Newark, DE Oberlin Filter Co. Waukesha, WI	Microfiltration	Palmerton Zinc Superfund Site Palmerton, PA (Region 3)	The demonstration plan is completed. The demonstration is planned for early 1990.	●	●	●	●			
	32. EPOC Water, Inc. Fresno, CA	Leaching and Microfiltration	None identified	This technology was accepted into the SITE Program in October 1989.	●						
Freeze Crystallization	33. Freeze Technologies Corporation Raleigh, NC	Physical Separation/ Concentration	Stringfellow Superfund Site Glen Avon, CA (Region 9)	The demonstration of a mobile pilot system is planned for spring 1990.	●	●	●	●			
Solvent Extraction	34. BioTrol, Inc. Chaska, MN	Soil Washing	MacGillis & Gibbs Superfund Site New Brighton, MN (Region 5)	The demonstration was conducted from September 24 through October 2, 1989.	●	●	●	●	●		
	35. C.F. Systems Corporation Waltham, MA	Solvent Extraction	New Bedford Harbor New Bedford Harbor, MA (Region 1)	The Technology Evaluation Report will be available in early 1990.	●	●	●	●	●	●	
	36. Dehydro-Tech Corporation East Hanover, NJ	Carver-Greenfield Extraction Process	None identified	Efforts to identify a demonstration site are underway.	●						
	37. Excaliber Enterprises, Inc. (formerly Ozonics Recycling Corporation) Key Biscayne, FL	Soil Washing/UV Oxidation with Ozone	None identified	Efforts to identify a demonstration site are underway.	●						
	38. Resources Conservation Co. Bellevue, WA	Solvent Extraction	None selected	Two remedial action sites with PCB-contaminated soil are under consideration. Treatability studies have been conducted at one site.	●						

Withdrawn Technologies	Weston Services, Inc. West Chester, PA	Low-Temperature Thermal Treatment (Evaporation and Steam Stripping)	Tinker Air Force Base Oklahoma City, OK (Region 6)	Withdrew from the program in January 1989 due to permit requirements that resulted in long delays.
	CBI Freeze Technologies, Inc. Plainfield, IL	Physical Separation/ Concentration (Freezing Crystallization)	Monsanto Site Lamarque, TX (Region 6)	Withdrew from the program in June 1989 because their technology was not ready for demonstration.
	Sanitech, Inc. Twinsburg, OH	Ion Exchange	None selected	Removed from the program in September 1989 because an acceptable demonstration site could not be identified.

AquaDetox and SVE Systems. The GAC is regenerated by steam. Water treated by GAC is reinjected into the ground to enhance VOC removal by the SVE System. Residuals generated by the system are a free-phase recyclable product, nonregenerable granular activated carbon, and treated water.



DOW Chemical Company's AquaDetox Steam Stripping Tower

Demonstration Status. Lockheed Aeronautical Systems has been using the full-scale system since September 1988 as part of the cleanup of the San Fernando Valley Superfund site, Area I, in Burbank, California. Groundwater and soil at the site are contaminated with VOCs, principally trichloroethylene and perchloroethylene. The SVE System is extracting 300 cubic feet per minute of soil gas that has a total VOC concentration of 6,000 ppm. The AquaDetox system is removing and treating 1,000 gallons of groundwater per minute. The proposed SITE demonstration, scheduled for spring 1990, will evaluate the ongoing remediation effort at the San Fernando Valley Superfund site in Burbank, California.

Chemical Waste Management, Inc.

Technology Description. Chemical Waste Management, Inc. (CWM), of Riverdale, Illinois, has developed a mobile thermal desorption system, called X*TRAX™ that has been designed to treat waste solids or sludges containing organics. The X*TRAX™ system employs a process in which solids with organic contamination are indirectly heated, driving off the water and organic contaminants and producing a dry solid containing trace amounts of organic residue. The system consists of two parts--the dryer trailer and off-gas trailer. The dryer is an indirectly-fired rotary kiln. An inert nitrogen carrier gas is recirculated through the kiln to transport the volatilized water and organics to the off-gas handling system. In the off-gas handling system, the volatilized materials are condensed in a three-stage cooling and condensing train, removing most of the water and most of the volatile and semivolatile organics. The nitrogen is then passed through a carbon adsorption system to remove the remaining organics. The X*TRAX™ is designed to treat soils contaminated with PCBs, but can be applied to pond or process sludges and filter cakes contaminated with up to 10% PCBs or other organic contaminants. Treatment residues include treated soils, liquids and sludges, and spent carbon. Some residues can be recycled within the system.

Demonstration Status. CWM has conducted tests on both laboratory- and pilot-scale systems. The pilot-scale system has been operating at CWM's Kettleman Hills, California hazardous waste facility since July 1989, testing PCB-contaminated soils under a TSCA R&D permit. EPA plans to conduct the SITE demonstration at the Kettleman Hills facility in spring 1990. Current plans are to test three soils--two contaminated with PCBs and one contaminated with other organic chemicals. EPA's primary objectives for the demonstration are to evaluate the performance of the system in removing these contaminants from soils, and to determine how contaminants removed from soil are collected in the gas treatment trailer.

Solvent Services, Inc.

Technology Description. Solvent Services, Inc., of San Jose, California, uses a Steam Injection and Vacuum Extraction (SIVE) process for *in-situ* soil remediation. Steam is forced through contaminated soil via injection wells to thermally enhance the vacuum extraction process. Recovered gaseous contaminants are either condensed and processed along with recovered liquids or trapped on activated carbon filters. The SIVE process is designed to treat soil contaminated with volatile and semivolatile organic compounds in parts per billion to percent level concentrations.

The treatment period is dependent upon the type and physical properties of the soil, and the type, distribution, and concentration of contaminants. Wastes generated by this system are spent carbon and contaminated water. Further treatment of recovered liquids may be necessary.

Demonstration Status. A six-month test of this technology is planned for 1990 at the Solvent Services, Inc., site in San Jose, California. The 1.2-acre demonstration site contains approximately 30,000 cubic yards of soil contaminated with various volatile organic substances, including acetone and toluene. The site should be fully remediated by the end of the test period. Evaluation of the technology's performance will be based on sampling of the site at completion of the demonstration, extensive pretest soil data, and systems operating data.

Terra Vac, Inc.

Technology Description. This *in-situ* vacuum extraction technology, developed by Terra Vac, Inc., of Dorado, Puerto Rico, is a process for the removal and venting of VOCs from the vadose or unsaturated zone of soils. Often, these compounds can be removed from the vadose zone before they have a chance to contaminate groundwater. In using this technology, subsurface organic contaminants are "vacuumed up" via a well, vapor/liquid separated, and then exposed to activated carbon before the "vapor" is allowed to be released into the atmosphere.

The technology uses readily available components such as extraction and monitoring well(s), manifold piping, vapor/liquid separator, vacuum pump, and emission control equipment, such as activated carbon canisters. Once a contaminated area is completely defined, an extraction well is installed and connected by piping to a vapor/liquid separator device. A vacuum pump draws the subsurface contaminants through the well, the separator device, and an activated carbon canister before the air stream is discharged to the atmosphere. Subsurface vacuum and soil vapor concentrations are monitored using vadose zone monitoring wells.

Demonstration Status. From January to April 1988 the Terra Vac vacuum extraction process was used to extract volatile contaminants from soils at the Groveland Wells Superfund site in Groveland, Massachusetts. In that area of the site, waste oils and degreasing solvents have contaminated the subsurface soils with VOCs (principally trichloroethylene) and with lesser concentrations of 1,2-dichloroethane and tetrachloroethylene. Most of the contamination occurs beneath a concrete slab that is used as a storage platform and above the water table.

Four extraction wells were employed to pump contaminants to the process system. Four monitoring wells were utilized to measure the impact of treatment on site contamination. The demonstration test objectives were to: (1) determine the ability of the technology to remove VOCs from the vadose zone, (2) assess the effectiveness of the technology in various soil types, (3) correlate declining recovery rates with time, and (4) correlate VOC concentrations in soils with those in extracted vapors. The eight-week demonstration produced the following results:

- Approximately 1,300 lbs of VOCs, mainly trichloroethylene (TCE) were extracted from the vadose zone.
- The process removes VOCs from soils of low, as well as high, permeability.
- There was a steady decline in the VOC recovery rate as a function of time of treatment.
- There was a marked reduction in soil VOC concentration in the test area.

Applications Analysis. The Terra Vac *in-situ* vacuum extraction process has been used at over 60 waste sites for recovery of gasoline, carbon tetrachloride, and TCE. The *Applications Analysis Report* documents four case studies, including efforts at three Superfund sites. As a result of the successful SITE demonstration, Terra Vac was hired to remediate the Groveland Wells Superfund site. Terra Vac has also been selected for at least three other clean-ups--Tinkham's Garage in Region I, Tyson's Dump in Region III, and Verona Wells Field in Region V.

The applications analysis results are summarized below:

- The major considerations in applying the technology are the contaminant compound's volatility, site soil porosity, and the site-specific cleanup level.
- The process performed well in removing VOCs from soil with measured permeability ranging between 10^{-4} and 10^{-8} cm/sec. In practical terms, the process works well with most soil types including clays, and under most geological conditions.
- The air-filled porosity of a soil is an important criteria to indicate whether vacuum extraction will work. Soils with low permeability but with adequate air-filled porosity are amenable to treatment by this process. Soils with high water content may require extensive dewatering before the process begins to work.
- Based on available data, typical treatment costs are approximately $50 per ton. Costs can be as low as $10 per ton at large sites not requiring off-gas or wastewater treatment. Costs for small sites may range as high as $150 per ton.

Toxic Treatments (USA), Inc.

Technology Description. Toxic Treatments (USA), Inc. (TTUSA), of San Mateo, California, has developed the Detoxifier, an *in-situ* method of removing volatile organics from soil using steam and heated air to strip the contaminants. The transportable unit uses drills that have been modified to allow for the expulsion of steam and air through the cutting blades. First, the soil is made permeable by the blades on the drills. Then steam and air are injected to strip the organic contaminants and carry them to the surface. A metal box (called a shroud) covers the treatment area to trap and transport the stripped volatiles to the treatment trailer. The water and organics in the gases are condensed, then separated and recovered.

The technology is applicable to organic contaminants such as hydrocarbons and solvents with sufficient partial pressure in the soil. The remediation depth must be less than 27 feet, and the ground should contain no obstacles larger than 14 inches in diameter.

Toxic Treatments (USA), Inc.'s *In-Situ* Steam Extraction System

Demonstration Status. In September 1989, a full-scale prototype of the *in-situ* Detoxifier was demonstrated. The test was conducted at the Annex Terminal site in San Pedro, California, a former storage and transfer facility for bulk liquid chemicals. About 7,500 cubic yards of soil at the site are contaminated with common industrial chemicals, chlorinated solvents, plasticizers, adhesives, and paint additives. Twelve soil blocks were treated for the demonstration. The area treated at each shroud setting was about 7.5 feet x 4 feet. Depth of treatment for this site was 5 feet.

EPA monitored the treatment system's operation for about one month of eight hours per day operation. The system was online most of the time. In addition to soil samples taken before and after treatment, EPA collected samples of treated air and water, and the condensed organics. A dye was also injected before treatment to track any downward migration. If early results of EPA's testing and additional testing by TTUSA are satisfactory, the remainder of the site will be remediated using this method. Preliminary test data should be available in spring 1990.

Filtration

Filtration is a process of separating and removing suspended solids from a liquid by passing the liquid through a porous medium. The porous medium may be a fibrous fabric (paper or cloth), a screen, or a bed of granular material. The filter medium may be precoated with a filtration aid, such as ground cellulose. Fluid flow through the filter medium may be accomplished by gravity, by inducing a partial vacuum or by exerting pressure on one side of the medium. Filtration is used for the dewatering of sludges and slurries as a pretreatment for other processes. This process is suitable for organic or inorganic chemical sludges, metals, and cyanides bound up in hydroxide sludges. Two of the 13 physical treatment technologies in the SITE Program involve filtration processes.

E.I. DuPont de Nemours, Inc./Oberlin Filter Company

Technology Description. E.I. DuPont de Nemours, Inc., of Newark, Delaware, has developed a microfiltration process that removes heavy metals and suspended solids from aqueous waste streams. In this treatment, DuPont's Tyvek™ filter media is used in combination with an automatic pressure filter provided by the Oberlin Filter Company of Waukesha, Wisconsin. The Tyvek™ material, in roll goods form, provides for filtration down to 0.1 micron with excellent chemical resistance and strength, while the Oberlin filter produces a relatively dry filter cake and allows unattended filtration capability. The mobile system may be used to treat any aqueous waste that contains hazardous solids or dissolved constituents that can be induced to precipitate. Metal particles, metal hydroxides and oxides, radioactive particulates, organic solids, and cyanide wastes have been successfully separated by the system.

Demonstration Status. Demonstration of a small unit (2.4 square feet) is scheduled for early 1990 at the Palmerton Zinc Superfund site in Palmerton, Pennsylvania. Groundwater at the site is contaminated with high concentrations of zinc and other heavy metals.

EPOC Water, Inc.

Technology Description. EPOC Water, Inc., of Fresno, California, has developed a process to decontaminate soils and sludges by leaching and microfiltration. This process can be used to decontaminate sludges or soils containing heavy metals, including barium, cadmium, chromium, lead, molybdenum, mercury, nickel, selenium, silver, and zinc. The process is relatively insensitive to metal content, and can process solids with metal concentrations of up to 10,000 mg/kg. In most situations, leaching can be accomplished using low-cost mineral acids or alkalis. In special circumstances, chelating agents can also be used to remove a particular metal. The leached slurry containing the solubilized metals is separated from the other solids by a tubular filter press. The resulting filtrate is chemically treated to precipitate the heavy metals in hydroxide form. Residual organic contamination in the precipitate can be removed with activated carbon. Heavy metals in the precipitate are separated and concentrated by microfiltration, using an innovative and flexible woven textile material that can separate particles as small as 0.1 micron.

Demonstration Status. This technology was accepted into the SITE Demonstration Program in October 1989. The demonstration unit is transportable and is designed to process approximately 30 lbs/hour. EPA is working with EPOC to identify a suitable demonstration site.

Freeze Crystallization

Freeze crystallization is a physical separation process used to remove pure components from solutions by crystallizing the materials to be removed. When a solution is partially frozen, a mixture of the ice crystals and solution is formed. The ice crystals formed in this situation essentially contain only pure water. These ice crystals, when separated from the mother liquor (brine), washed and melted, produce salt free water. The mother liquor retains essentially all foreign elements originally present and becomes concentrated as a result of water removal. This process is suitable for dilute aqueous organic and inorganic waste solutions usually containing less than 10% total dissolved solids.

Freeze crystallization has several advantages for remediation and waste recovery applications. It is a very efficient volume reduction process, producing a concentrate that has no additional chemicals added to it. If disposal in a hazardous waste landfill or incinerator destruction is required, freeze crystallization can substantially reduce the landfill or incineration costs. When a large fraction of the solvent (usually water) is removed from a waste, the remaining impurities often begin to crystallize as well. They are often sufficiently pure to have byproduct value for resale. One of the 13 physical treatment technologies in the SITE Program involves freeze crystallization.

Freeze Technologies Corporation

Technology Description. Freeze Technologies Corporation, of Raleigh, North Carolina, uses freeze crystallization to separate organics and inorganics from heavily contaminated aqueous and liquid wastes. Coolant is added to the waste to create an icy slush. The ice crystals are then recovered and washed with pure water to remove adhering brine contaminants. The difference between this process and other freeze crystallization processes is the freezing process. In the Freeze Technologies process, the mixed waste liquid enters through the feed heat exchange where it is cooled to within a few degrees of its freezing temperature. The cooled feed then enters the crystallizer where it is mixed with boiling refrigerant. Water is crystallized in the stirred solution, and is maintained at a uniform concentration or ice fraction by continuous removal of a slurry stream. Ice slurry from the crystal separator can be washed and melted as any other freeze crystallization process. Residuals generated by this process include treated water and concentrated waste sludge, typically 10% of the original waste volume. This technology will remove both organic and inorganic, and ionic and non-ionic species from contaminated aqueous streams. It works on both surface waters and groundwaters as well as directly on process wastes and mixed wastes.

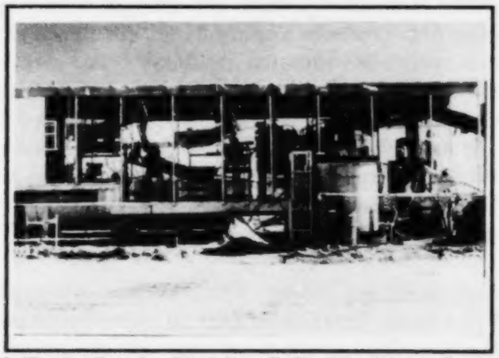
Demonstration Status. Treatability studies have been completed. In spring 1990, Freeze Technologies will demonstrate a mobile pilot system that will process 5-10 gallons/minute at the Stringfellow Superfund site in Glen Avon, California. The groundwater at the site contains a wide variety of organic and inorganic contaminants.

Solvent Extraction

Solvent extraction is based on the solubility of the hazardous chemicals in various solvents to perform the physical separation process. When a waste stream contacts with the particular solvent, hazardous materials dissolve as solute and are removed from the waste stream. After separating the solvent and solute from the waste stream, further treatment can be performed to detoxify these hazardous materials. This process is suitable for aqueous waste streams contaminated with single or multiple component dissolved organic wastes and sludge contaminated with oils, toxic organics, and heavy metals. Five of the 13 physical treatment technologies in the SITE Program involve solvent extraction processes.

BioTrol, Inc.

Technology Description. BioTrol, Inc., of Chaska, Minnesota, has developed a soil washing system to treat soil contaminated with oil, PCP, and creosote from wood-preserving sites. The system consists of a soil washer, a slurry bioreactor, and the fixed-film bioreactor used in the BioTrol Aqueous Treatment System. The soil washer uses water in a multi-staged series of intensive scrubbing to separate the heavily contaminated fine fraction (silt, clay, and humic particles) of the soil from the coarser, less contaminated sand fraction. All process water used in the soil washer is treated in the fixed-film bioreactor prior to discharge or recycle. The soil washing system was operated successfully over a two-year period at a wood treating site in Minnesota. During this time, biological treatment of the process water from soils washing was also successfully demonstrated. In 1989, BioTrol, Inc., added slurry biodegradation technology to treat the fine particle sludge generated by washing of soils contaminated by degradable, organic contaminants.



BioTrol, Inc.'s Mobile Soil Washing System

Demonstration Status. The SITE demonstration of the BioTrol soil washing technology took place in September and October 1989 at the MacGillis & Gibbs Superfund site in New Brighton, Minnesota. A pilot-scale unit with a treatment capacity of 500 to 1,000 lbs/hour was demonstrated. For two days, the soil washer processed 24,000 pounds of soil containing about 300 ppm PCP, followed by a 7-day test on 46,000 pounds of soil containing about 1,000 ppm PCP. The operation of the soil washer was continuous (around the clock). EPA sampled all input and output streams, and will analyze samples for PCP, PAHs, chlorinated dioxins and furans, and certain metals. During an 11-day test, process water from soil washing was treated in the fixed-film bioreactor and recycled back to soil washing. A small portion of the fine particle slurry was treated by a prototype suspended solid bioreactor developed by EIMCO Process Equipment Company of Salt Lake City, Utah. During the two-week test about 180 gallons (200 pounds) of fine particle slurry resulting from the soil washer test on the highly contaminated soil was treated.

C.F. Systems Corporation

Technology Description. C.F.Systems Corporation, of Waltham, Massachusetts, has developed a solvent extraction process. The technology is unique as it uses liquefied gases (propane or carbon dioxide) as solvents to remove organic constituents, such as hydrocarbons and oil and grease, from sludges, solids, and liquid wastes. The system uses vapor recompression and conventional distillation to recycle the solvents and concentrate the organic constituents.

Contaminated material is fed into the top of the extractor while liquefied gas flows upward through the extractor, making non-reactive contact with the waste. Clean material is removed from the bottom of the extractor while the mixture of solvent and organic contaminant moves from the extractor to the separator through a pressure reducing valve. In the separator, the solvent is vaporized and recycled, while the organic contaminants are drawn off as a concentrate for further treatment or disposal.

Demonstration Status. During the month of September 1988, C.F. Systems' solvent extraction technology was pilot tested on PCB-contaminated harbor sediments from the New Bedford Harbor Superfund site in Massachusetts. The major objective of the demonstration was to evaluate the ability of the extraction system to remove and concentrate PCBs from the sediments.

Contaminated sediments were treated with C.F. Systems' trailer-mounted Pit Cleanup Unit (PCU) that has a design capacity of 1.5 gallons/minute or 20 barrels/day. During the demonstration, PCB concentrations and residence times were varied for each of four tests. Each test consisted of a number of passes, or runs, through the pilot-scale unit. These data were necessary for design of the full-scale unit. During the 30-day demonstration, 300 lbs of harbor sediment containing PCBs and heavy metals were treated. Samples were taken at various points in the treatment stream. Extraction efficiencies were high, despite some operating difficulties during the tests. The use of sediment as feed to the next pass caused cross-contamination in the system. Full-scale commercial systems are designed to eliminate the problems associated with the pilot-scale design.

Applications Analysis. Commercial systems have been sold to Clean Harbors, Braintree, Massachusetts, for wastewater cleanup, and Ensco of Little Rock, Arkansas, for incinerator pre-treatment. A full-scale unit (200 barrels/day) is in operation at Star Enterprise, Port Arthur, Texas, treating API separator sludge to meet Best Demonstrated and Available Technology (BDAT) standards for organics.

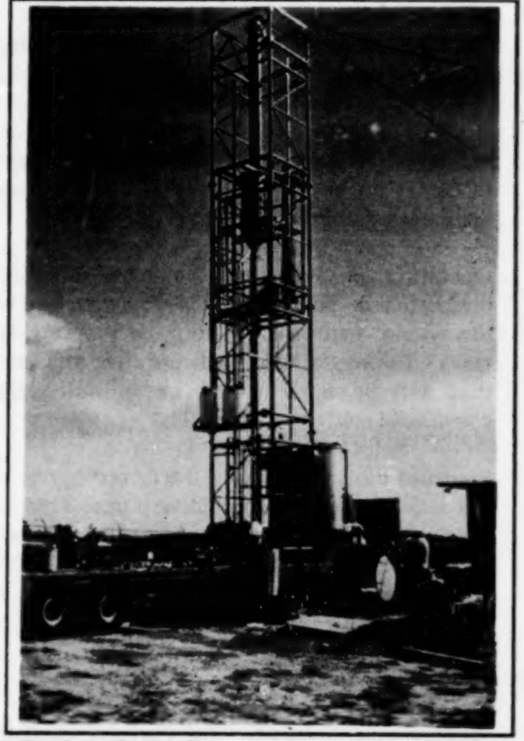
The applications analysis resulted in the following conclusions:

- Extraction efficiencies of 90-98% were achieved on sediments containing between 350 and 2,575 ppm PCBs. PCB concentrations were as low as 8 ppm in the treated sediment.
- Operating problems at the New Bedford demonstration included solids being retained in the system hardware and foaming in receiving tanks. The vendor identified corrective measures that will be implemented in the full-scale commercial unit.
- Projected costs of applying the technology to a full-scale cleanup effort could vary from $148 to $448 per ton, including pre- and post-treatment costs, materials handling, costs for specialized process design, and the predicted onstream factor for a full-scale unit.

Dehydro-Tech Corporation

Technology Description. The Carver-Greenfield Process for extraction of oily waste, developed by Dehydro-Tech Corporation, of East Hanover, New Jersey, is a system that removes various oil-soluble hazardous organic contaminants (hydrocarbons and chlorinated hydrocarbons) from sludges, soils, and other waste feeds by extraction into food-grade oil. The process involves slurrying the waste feed material with a recirculating, food-grade "carrier" oil; evaporating water from the slurry in a high-efficiency evaporation system; and separating the oil and feed in a centrifuge; followed by a second slurrying and centrifuging step. Recirculated oil is distilled to recover the organic contaminants, and solids undergo a hydroextraction step to remove residual oil. Treatment products from the process include clean, dry solids; water virtually free from solids and oils, which may require minimal treatment for low-level organics; and a concentrated mixture of the extracted oil-soluble compounds, which may be incinerated or otherwise disposed. The

Carver-Greenfield process can treat sludges, soils, and other water-bearing wastes containing oil-soluble hazardous compounds, including PCBs and dioxins. The process has been commercially applied to municipal petroleum tank bottoms, paper mill sludge, municipal sewage sludge, and pharmaceutical plant waste.



Deyhro-Tech Corporation's Mobile Oily Waste Extraction Unit

Demonstration Status. The treatment system to be tested is a pilot-scale mobile unit installed on one 40-foot trailer with a height of 8 feet. Capacity of this system is about 50 lbs/hr, and approximately 5,000 to 10,000 lbs of feed material are needed for a two to three week test. Efforts to identify a demonstration site are underway.

Excaliber Enterprises, Inc. (formerly Ozonics Recycling Corporation)

Technology Description. Excaliber Enterprises, Inc., of Key Biscayne, Florida, has developed a soil washing technology that combines enhanced soil washing of both organics and inorganics with treatment of the washwater with ozone oxidation catalyzed by ultraviolet light and ultrasonic waves. Any metals present in the rinsewater are removed with conventional metals treatment. Ultrapure water, combined with a biodegradable surfactant and ultrasound, is used as a solvent in the washing process. Contaminated rinsewater is pumped into the reactor chamber and combined with ozone, which oxidizes contaminants to carbon dioxide, water, and harmless salts. The use of UV light and ultrasonic waves in the reactor can reduce the total organic carbon in the rinsewater three times more rapidly than ozone alone. This technology may be applied to soils, sludges, and liquids containing metals and toxic organics, such as PCBs, PCP, herbicides, and pesticides. Residuals of the process are treated water, clean soil, and metals sludge.

Demonstration Status. The SITE demonstration will test a transportable pilot system that treats 1-5 tons of soil per day. The major objectives of the demonstration are to determine the effectiveness of the soil washing on organic and inorganic contaminants, and the oxidation process on organics in the washwater. The waste preferred for the demonstration is soil contaminated with PCBs or PCP, and combined with metals (such as chrome, copper, arsenic). About 50 tons of soil are needed for a one-month demonstration. Efforts are underway to identify a suitable demonstration site.

Resources Conservation Co.

Technology Description. The Basic Extraction Sludge Treatment (B.E.S.T.TM) process, developed by Resources Conservation Co., of Bellevue, Washington, is used to de-water and de-oil contaminated sludges and soils, including those containing PCBs. The process uses differences in chemical solubility of triethylamine (TEA) in water at different temperatures to break waste into three constituents--dischargeable water, oil and organics, and dry oil-free solids. Heavy metals are isolated by conversion to hydrated oxides which precipitate out and exit the process with the solids fraction.

The technology has application to difficult-to-handle oily sludges, oils, or PCB-contaminated soils and sediments. There are no special climatic restrictions to the B.E.S.T.TM system, although some system modifications may be required in extremely cold climates.

Demonstration Status. The first full-scale B.E.S.T.TM unit was used as part of a removal action at the General Refining Superfund site in Garden City, Georgia. Two sites with PCB-contaminated soils are being evaluated to determine their suitability for demonstrating the B.E.S.T.™ process.

Withdrawn Physical Treatment Technologies

In January 1989, Weston Services, Inc., withdrew its technology from the SITE Program due to permit requirements that resulted in long delays to evaluate their process. CBI Freeze Technologies, Inc., withdrew its physical separation technology from the SITE Program in June 1989 because the technology was not ready for demonstration. In September 1989, Sanitech, Inc., was removed from the SITE Program because an acceptable demonstration site could not be identified for their ion exchange technology.

III. EMERGING TECHNOLOGIES PROGRAM

The Emerging Technologies Program provides a framework to encourage the bench- and pilot-scale testing and evaluation of technologies that have already been proven at the conceptual stage. The goal is to promote the development of viable alternatives available for use in Superfund site remediations. The emerging technologies may then be considered for the SITE Demonstration Program, for field demonstration and evaluation.

Technologies are solicited for the Emerging Technologies Program through Requests for Proposals. Each July, EPA advertises in the *Commerce Business Daily* and trade journals for submission of preproposals. Following a technical review of these preproposals, 15-20 offerors are invited to submit full proposals and to enter into the competitive cooperative agreements application process. Selected technology developers receive a maximum of two years' funding to enable them to move their technologies toward commercialization. The program provides awards of up to $150,000 per year, for a maximum of $300,000 over two years. However, second-year funding depends on the achievement of significant progress during the first year. Three solicitations have been issued to date--in September 1987 (E-01), July 1988 (E-02), and July 1989 (E-03). The Emerging Technologies Program currently includes a total of 15 bench- and pilot-scale technologies. The selection of E-03 projects is expected in early 1990.

The major accomplishments of the Emerging Technologies Program for FY 1989 are as follows:

- Results to date were sufficiently encouraging to warrant approval of second-year funding for five of the E-01 projects.
- Seven new bench- or pilot-scale technologies were accepted under the E-02 solicitation, and one additional technology under the E-01 solicitation.
- EPA has evaluated 47 preproposals as a result of the E-03 solicitation issued in July 1989. In early 1990, EPA may approve an expanded number of emerging technologies from this solicitation.

A. ACCOMPLISHMENTS

1. E-01 Emerging Technologies

The first year of study has been completed for the seven projects initially funded under E-01. An eighth project was subsequently added in 1989 due to availability of funds. The eight projects received a total first-year funding of approximately $1,000,000. The projects are evaluating the use of manmade wetlands to remove and accumulate metals from influent waters, chemical treatment combined with ultrafiltration to remove heavy metal ions from aqueous waste solutions, laser stimulated photochemical oxidation to remove toxic organics from groundwater, a biological sorption process to remove heavy metal ions from groundwater, soil washing with a blend of solvents to cleanse contaminated soils, and steam extraction and electroacoustics for *in-situ* treatment to remove organic and inorganic contaminants from soils.

Results to date were sufficiently encouraging to warrant approval of second-year funding for five of the projects: Atomic Energy of Canada, Ltd., Colorado School of Mines, Energy and Environmental Engineering, Inc., Harmon Environmental Services, Inc., and Western Research Institute. The sixth project, Bio-Recovery Systems, Inc., was a one-year project not requiring additional funds, and the seventh project, Battelle Memorial Institute, will be discontinued due to lack of commitment by the developer. Although five of the projects are mid-way in their project period and significant conclusions at this point in time are premature, some of the accomplishments noted to date are described below for each project. The E-01 emerging technologies are listed in Exhibit III-1, along with a description of the status of the project.

Atomic Energy of Canada, Ltd.

Atomic Energy of Canada, Ltd. (AECL), Chalk River, Ontario, is preparing a laboratory-scale demonstration technology to extract dissolved toxic metals from groundwater. The technology uses ultrafiltration in combination with chemical treatment to selectively remove dissolved metal ions from dilute aqueous waste solutions.

EXHIBIT III-1. STATUS OF E-01 EMERGING TECHNOLOGIES IN THE SITE PROGRAM

DEVELOPER	TECHNOLOGY	STATUS
Atomic Energy of Canada, Ltd. Chalk River, Ontario	Chemical Treatment/ Ultrafiltration	During the first year's work, AECL has successfully separated cadmium, lead, and mercury ions, even in the presence of an organic compound (toluene). Second-year funding for the project has been approved.
Battelle Memorial Institute Columbus, OH	Electroacoustic/Soil Decontamination (ESD)	Phase I studies show that the ESD process is only marginally effective for hydrocarbon removal. Therefore, the project will not enter Phase II. The project has not been approved for second-year funding.
Bio-Recovery Systems, Inc. Las Cruces, NM	Algal Sorption of Metals	A pilot-scale demonstration of the AlgaSORB™ process was carried out on mercury contaminated groundwater at an industrial facility in Oakland, California, in September 1989. This is a one-year project and the final report is in preparation.
Colorado School of Mines Golden, CO	Constructed Wetlands	The pilot-scale wetland has reduced toxicity by a factor of 4-20 times and removed most of the zinc and copper from the drainage. Second-year funding for the project has been approved.
Energy and Environmental Engineering, Inc. Somerville, MA	Laser Stimulated Photochemical Oxidation	Testing is continuing on the types of compounds that can be destroyed by the activity of the laser beam into the contaminated water. Second-year funding for the project has been approved.
Harmon Environmental Services, Inc. (Formerly Envirite Field Services, Inc.) Atlanta, GA	Soil Washing	Laboratory and pilot-scale programs are complete. Harmon has submitted their interim report. Second-year funding for the project has been approved.
Membrane Technology and Research, Inc. Menlo Park, CA	Membrane Process for VOC Removal	The project was initiated on July 1, 1989. The cooperative agreement has been signed. A planning meeting was held on August 9, 1989. A draft QAPP was submitted to EPA for review in September 1989.
Western Research Institute Laramie, WY	Contained Recovery of Oily Wastes	A number of hot water leaching tests have been completed. Second-year funding for the project has been approved.

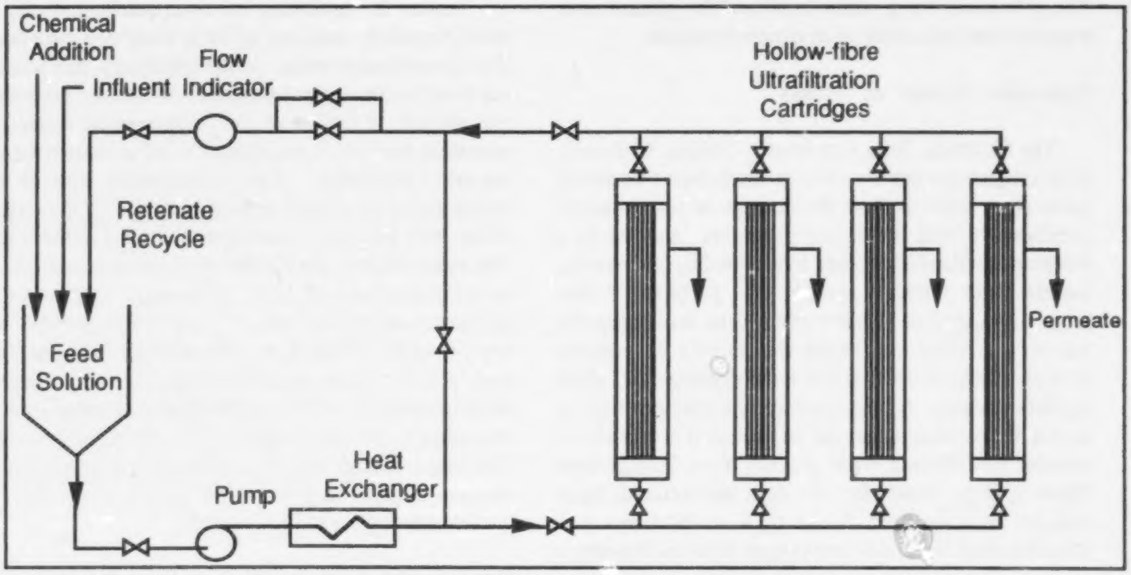


Exhibit III-2. Atomic Energy of Canada, Ltd.'s Mobile Ultrafiltration Unit

During the first year's work, bench-scale tests were conducted to identify dominant variables affecting membrane fouling as well as metal removal efficiencies. The results of these tests showed the following removal rates: up to 99% for cadmium and mercury, 90% for lead, and 10-35% for arsenic. The research also indicated that ultrafiltration, unlike conventional precipitation technologies, does not require the production of large particles, and thus may be more applicable to feed streams with high variability in metals concentration. During the second year of the project, AECL will prepare and field-test a pilot-scale mobile separation unit.

Battelle Memorial Institute

Battelle Memorial Institute, Columbus, Ohio, is investigating the Electroacoustic Soil Decontamination (ESD) process for *in-situ* treatment of soils contaminated with fuel oil, hazardous organic compounds, and heavy metals. This technology decontaminates soils through the application of electrical (direct current) and acoustic fields. These direct currents facilitate the transport of liquids through soils. The process consists of electrodes and an acoustic source.

The first year's results indicate that the ESD process is a feasible technology for removing inorganic species (i.e., zinc and cadmium) from clayey soils; it is only marginally effective for hydrocarbon removal. To date, the ESD process has not been applied to *in-situ* site remediation. Consequently, any further work on hydrocarbon removal was not recommended. Battelle Memorial Institute was unable to obtain cost sharing commitments from their industrial partners for the second year. Therefore, efforts for the first year continued through December 31, 1989, and a camera-ready copy of the Phase I final report will be prepared.

Bio-Recovery Systems, Inc.

Bio-Recovery Systems, Inc., Las Cruces, New Mexico, is testing AlgaSORB^R, a new technology for the removal and recovery of heavy metal ions from groundwater. AlgaSORB^R is a biological sorption process based on the affinity of algae cell walls for heavy metal ions.

Treatability studies showed that mercury contaminated samples containing 170 ppb of mercury with a pH of 1.8 can be removed well below the required 10 ppb discharge limit. A pilot-scale demonstration of the AlgaSORB^R process was carried out on mercury-contaminated groundwater at an industrial facility in Oakland, California, in September 1989. This one-year project is expected to be completed by January 31, 1990. Testing was designed to determine optimum flow rates, binding capacities, and efficiency of stripping agents.

The process is being commercialized for groundwater treatment and industrial point source treatment.

Colorado School of Mines

The Colorado School of Mines, Golden, Colorado, is investigating a constructed, wetlands-based treatment technology predicated on the concept of using natural geochemical and biological processes inherent in a manmade wetland ecosystem to accumulate and remove metals from influent waters. The purpose of this project, initiated in October 1988, is to investigate the use of constructed (manmade) wetlands for the removal of toxic metals from mineral mine drainage and other aqueous streams. A pilot-scale system has been built to assess the effectiveness of constructed wetlands in treating the effluent from the Big Five Tunnel near Idaho Springs, Colorado. To date, the wetlands have reduced toxicity by a factor of 4 to 20 times and removed most of the zinc and copper from the drainage.

Energy & Environmental Engineering, Inc.

Energy & Environmental Engineering, Inc., Somerville, Massachusetts, is investigating a technology designed to photochemically oxidize organic compounds in wastewater by applying ultraviolet radiation using a laser beam. This process is envisioned as a polishing step in treating organic contamination in groundwater drawn from a hazardous waste site or industrial wastewater prior to discharge.

Testing is continuing on compounds that can be photochemically oxidized by the activity of a laser beam into contaminated water. In the laboratory, this process has been used to destroy benzene, chlorinated benzenes, and phenol. Aeration of the contaminated water just preceding the laser beam appears to aid in destroying the organic molecules. This is probably due to the formation of an oxygen radical or ozone by the energy of the laser beam on the oxygen dissolved in the water. The most efficient destruction of chlorobenzene occurs at concentrations of 12.5 to 50 mg/L in the water; efficiency is less when the concentration is either too low (3 mg/L) or too high (100 mg/L). In the second year, actual leachate containing phenols will be tested, and a revised pilot-scale unit will be built incorporating operational changes suggested by the results to date. One major change will be to shorten the length of the reaction chamber as almost all of the reaction occurs in the first few inches of the chamber.

Harmon Environmental Services, Inc.

Harmon Environmental Services, Inc. (formerly Envirite Field Services, Inc.), Atlanta, Georgia, is conducting a series of laboratory tests on a soil washing process that uses a blend of solvents to cleanse soil contaminated with high molecular weight organic compounds, such as PCBs and dioxins. The solvents are then removed from the solid by steam stripping. The tests will determine how different soils separate from solvents using pressure filtration and centrifugation.

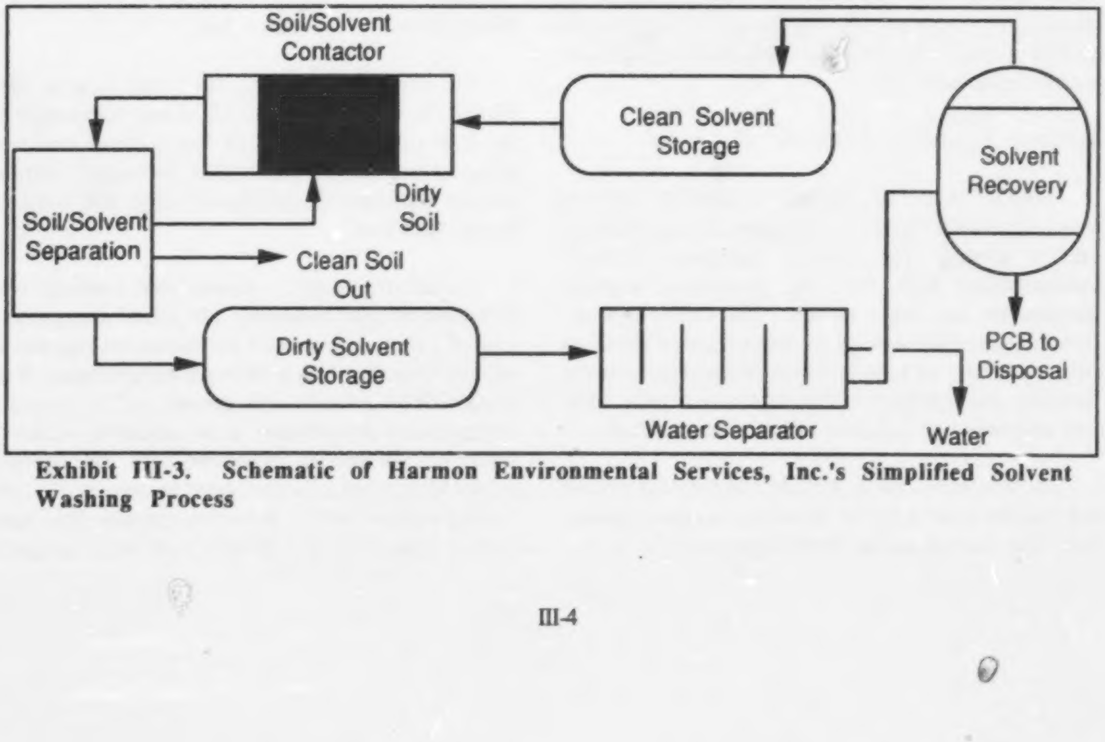


Exhibit III-3. Schematic of Harmon Environmental Services, Inc.'s Simplified Solvent Washing Process

Laboratory and pilot-scale programs are complete, and an interim report has been prepared. One hundred twenty laboratory tests were conducted using 12 soil types (various combinations of clay, organic matter, and sand), three solvents, and three separation techniques. Standard Analytical Reference Materials (SARMs) were also evaluated.

Membrane Technology and Research, Inc.

The availability of additional funds allowed EPA to accept an eighth emerging technology under the E-01 program. Membrane Technology and Research, Inc., Menlo Park, California, is developing a technology to treat contaminated air streams at hazardous waste sites. The contaminated vapor-laden air is drawn across a polymeric membrane that is permeable to organic vapor but relatively impermeable to air. The vapors are condensed and recovered as a liquid organic product suitable for recycling, disposal, or further treatment. A series of tests on waste streams containing octane, toluene, acetone, and 1,1,1-trichloroethane have shown that membrane technology may be applicable to waste streams generated at Superfund sites.

The cooperative agreement between Membrane Technology and Research, Inc. and EPA has been signed. The project was initiated on July 1, 1989 and is expected to be completed by June 30, 1990. A draft Quality Assurance Project Plan (QAPP) was submitted to EPA for review in September 1989.

Western Research Institute

The Western Research Institute, Laramie, Wyoming, is conducting several tests to recover oil and water from soils using conventional oil recovery technology and controlled injections of steam and hot and cold water. Residual organic pollutants in the soil are biodegraded to remediate the hazardous oily wastes. This technology can be applied to soils containing organic liquids, such as coal tars, PCP solutions, creosote, and petroleum byproducts. This technology is being tested at laboratory- and pilot-scale. A number of hot water leaching tests have been completed.

2. E-02 Emerging Technologies

EPA issued its second solicitation of the Emerging Technologies Program (E-02) on July 8, 1988. The E-02 solicitation focused on technologies designed to treat complex mixtures of hazardous organic and inorganic contaminants in sludge and soils by either *in-situ* or surface processes that separate, remove, destroy, detoxify, or stabilize the contaminants or provide for improved solids handling and pretreatment. Technologies that are applicable to only treating aqueous or air streams were considered but were of less interest. Likewise, technologies applicable to problems that exist at only a few Superfund sites were considered less desirable than those applicable to numerous Superfund sites.

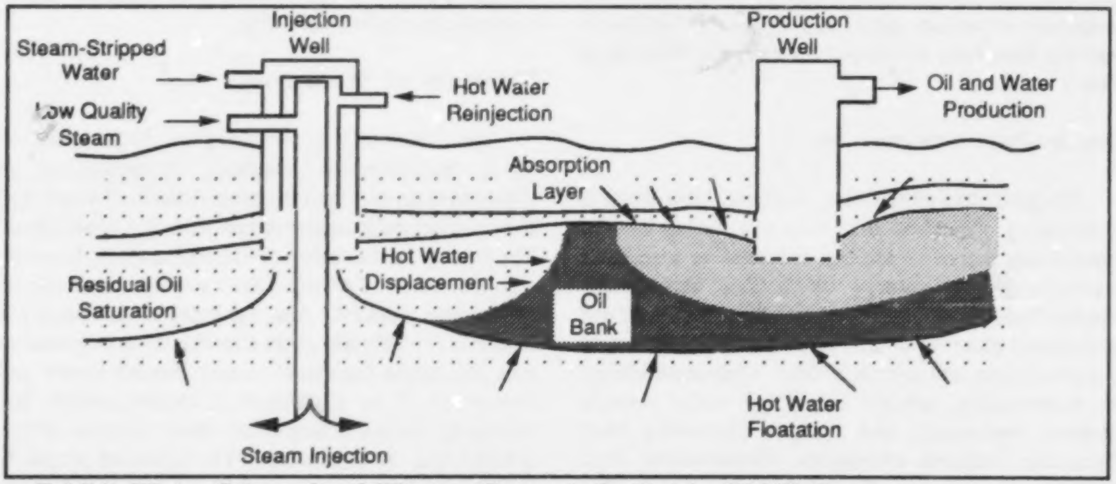


Exhibit III-4. Schematic of Western Research Institute's CROW Process

Sixty preproposals were received in response to the E-02 solicitation. These preproposals were reviewed by EPA in October 1988. Seven emerging technologies were selected for funding under the E-02 solicitation, and the technologies are described below. The E-02 emerging technologies are listed in Exhibit III-5, along with a description of the status of the project.

Babcock & Wilcox Company

Babcock and Wilcox Company, Contract Research Division, Alliance, Ohio, is testing a cyclone furnace to treat soils contaminated with metals and organic chemicals. The organic chemicals are incinerated and the metals are captured in a non-leachable slag. The cyclone combustor is a water-cooled horizontal cylinder attached to the main furnace in which fuel is fired at temperatures high enough to completely destroy the combustibles and melt the ash into a liquid slag. The unit is designed to destroy organic and inorganic solid, liquid, or gaseous contaminants.

Center for Hazardous Materials Research

The Center for Hazardous Materials Research, Pittsburgh, Pennsylvania, has successfully applied their Acid Extraction Treatment System (AETS) technology to remediation of soils, sludges, and ash contaminated with organics. Contaminants are removed via countercurrent extraction with an acid. This results in the detoxification of the input material stream. The contaminants concentrate in a separate stream for further treatment to remove metals and organics. The system has not been fully developed for effective removal of heavy metals.

Electro-Pure Systems, Inc.

Electro-Pure Systems, Inc., Amherst, New York, is developing a method that uses alternating current electrocoagulation to remove colloidal or suspended particles from water. With this technology electrochemical interactions enhance the liquid/liquid and solid/liquid phase separation process, without the use of polyelectrolyte and chemical aids. It has applicability to wastewaters, soluble oils, high water content slurries, sediments, and sludges containing both hazardous inorganic and organic contaminants. Risk minimization and economic viability will be assessed.

Enviro-Sciences, Inc.

Enviro-Sciences, Inc., Mt. Arlington, New Jersey, is testing the Low-Energy Solvent Extraction Process, which uses common hydrophilic and hydrophobic solvents to extract and concentrate hydrophobic organic pollutants from soils and sediments. The process is designed to remove PCBs and other organic contaminants from soils, sludges, and sediments from harbors, rivers, and lagoons. The technology is currently available for bench-scale treatability studies. Development of the pilot test bed is underway.

International Technology Corporation

International Technology Corporation (ITC), Knoxville, Tennessee, is investigating a two-step batch treatment process to treat soils contaminated with organics and heavy metals. In the first step, the volatile and semivolatile components are removed using batch steam distillation. In the second step, the heavy metals are extracted from the soil into an aqueous medium for recovery or disposal. The treated soil is returned to the site as a wet nonhazardous sludge. The equipment for the pilot-scale demonstration of the batch steam distillation/metal extraction treatment of contaminated Superfund soils is being assembled at the Oak Ridge, Tennessee, facility and arrangements are being made to obtain a variety of contaminated soils for testing. It is expected that pilot-scale tests will be conducted with a clay soil, a sandy soil, and a loamy soil. Each soil may contain different contaminants, since these are actual wastes from contaminated sites.

University of Washington

The University of Washington, Department of Civil Engineering, Seattle, Washington, is experimenting with an adsorptive filtration process that removes inorganic contaminants from the liquid phase. The process uses a variety of materials to adsorb metals onto the surface of minerals that have been immobilized on substrate particles. After the metal contaminants are separated from the adsorbent material, it can be reused to treat subsequent batches of wastes. Further testing and evaluation of an adsorptive filtration process for removing metals (inorganics) from aqueous waste streams will be conducted. The filtration media is ferrihydrite (iron oxide) coated on sand grains or

EXHIBIT III-5. STATUS OF E-02 EMERGING TECHNOLOGIES IN THE SITE PROGRAM

DEVELOPER	TECHNOLOGY	STATUS
Babcock & Wilcox Co. Alliance, OH	Cyclone Furnace	The cooperative agreement has been processed and sent to the developer.
Center for Hazardous Materials Research Pittsburgh, PA	Acid Extraction	The cooperative agreement has been processed and sent to the developer.
Electro-Pure Systems, Inc. Amherst, NY	Alternating Current Electro-Coagulation	A cooperative agreement was awarded August 14, 1989. A kickoff meeting was held August 25, 1989. The detailed workplan and QAPP are being developed.
Enviro-Sciences, Inc. Mt. Arlington, NJ	Low-Energy Solvent Extraction	A kickoff meeting was held in Mt. Arlington, New Jersey on August 31, 1989. The detailed workplan and QAPP are being developed.
International Technology Corporation Knoxville, TN	Batch Steam Distillation/Metal Extraction	The equipment for this project is being assembled at the Oak Ridge, Tennessee pilot plant facilities of ITC. The QA/QC plan is being prepared.
University of Washington Seattle, WA	Adsorptive Filtration	The draft workplan and QAPP were submitted to EPA on August 31, 1989 and are being reviewed.
Wastewater Technology Centre Ontario, Canada	Crossflow Pervaporation System	WTC has already begun developmental work on the system. EPA funding will go primarily toward construction and testing of a pilot-scale unit.

possibly activated carbon. This technology has been investigated extensively at the bench-scale level. Further bench-scale tests will be performed to establish optimal operating conditions and to evaluate the effects of organic complexation and particulates on treatment efficiency.

Wastewater Technology Centre

Wastewater Technology Centre (WTC), Ontario, Canada, is investigating the use of pervaporation, a demonstrated membrane technology, for the removal and concentration of VOCs from aqueous wastes. Two streams are produced by this process: a treated effluent free of VOCs, and a vapor containing concentrated VOCs. Both phases require further processing for decontamination. The separation unit will be constructed to allow contaminated material to flow across the outside of hollow fiber membranes while VOCs diffuse into the interior of the fibers. This design will minimize chances for plugging or fouling the unit with solids. The project objectives include: (1) optimization of membrane thickness, (2) development of a transversal-flow prototype module, (3) testing of the pilot-scale unit to provide scale-up data, and (4) verifying the economic analysis of the process. WTC has already begun developmental work on the system and EPA funding will go primarily toward construction and testing of a pilot-scale unit.

B. FUTURE ACTIVITIES

On July 7, 1989, EPA sent out 577 Requests for Proposal for the third solicitation (E-03) of the Emerging Technologies Program. The E-03 solicitation emphasized the following types of technologies:

- Treatment of solids (including soils and sludges) containing both organic and inorganic constituents, or only inorganic constituents.
- Materials handling techniques that improve pretreatment and post-treatment operations, including those that separate hazardous from nonhazardous components.
- Low-cost methods to treat large volumes of soil with relatively low contaminant concentration levels.
- Biological technologies for soils and sludges capable of treating organic contamination.
- Separation/extraction of low-level radioactive waste material from soils.
- *In-situ* treatment processes for soils that would provide alternatives to long-term conventional pump and treatment approaches to remediation.

On September 7, 1989, 47 proposals were received in response to the E-03 solicitation. Final selection of the technologies for the Emerging Technologies Program will be in March 1990. EPA may approve an expanded number of new emerging technologies as a result of the SITE E-03 solicitation.

There is a progressive trend in the SITE Program toward emphasizing *in-situ* technologies that address the treatment of soils and sludges, the treatment of mixed wastes containing low-level radioactive material, materials handling, and unit processes used in treatment trains. Future Emerging Technologies Program solicitations will continue to emphasize technologies that are applicable to treating complex mixtures of hazardous organic and inorganic contaminants in sludges and soils, as well as those technologies that are applicable to remediating numerous Superfund sites. The fourth solicitation for the Emerging Technologies Program is expected to be published in July 1990.

IV. MONITORING AND MEASUREMENT TECHNOLOGIES PROGRAM

The EPA Environmental Monitoring Systems Laboratory in Las Vegas, Nevada (EMSL-LV), has been supporting the development of innovative monitoring and measurement techniques in conjunction with the SITE Program. The SITE Program provides EPA with a good mechanism to identify and demonstrate monitoring and measurement technologies that exist within and outside the federal government and which may provide less expensive, better, and/or faster means to detect contaminants at hazardous waste sites.

In 1986, SARA charged EPA with effecting more timely, permanent, and cost-effective remedies at the nation's Superfund sites. Monitoring and measurement technologies are required in several phases of the Superfund remedial process. The costs incurred for site characterization are a direct result of sampling, analysis, and the associated quality assurance activities. Therefore, the capabilities of field screening methods to yield immediate or quick-turnaround environmental data will result in major savings in both cost and time for Superfund remediation, will decrease the human and ecological risks associated with Superfund sites, and will enhance the abilities to manage such risks.

Through EMSL-LV, monitoring and measurement technologies are evaluated to determine their ability to: (1) assess the extent of contamination, (2) determine effects on human health and the environment, (3) aid in the selection of the most appropriate remedial action, and (4) monitor the effectiveness of a selected remedy. The Monitoring and Measurement Technologies Program (MMTP) focuses only on technologies that detect, monitor, and measure hazardous and toxic substances in air, surface waters, groundwaters, soil, subsurface (saturated and vadose) zones, wastes, and biological tissues.

The MMTP has both an emerging technologies and a field demonstration component. In prior years, MMTP activities were conducted under the emerging technologies component as the program operated predominently as a research laboratory focusing on the developmental stage of monitoring and measuring technologies. MMTP activities are now moving toward the field demonstration component as monitoring and measurement technologies become ready for demonstration. During Fiscal Year 1989, the first two monitoring and measurement technologies were demonstrated at Superfund sites. These two technologies included:

- A field immunoassay kit and a laboratory-based immunoassay for measuring pentachlorophenol in groundwater, and
- Canister-based samplers and long-path optical systems (high resolution Fourier-transform infrared spectrometer) for monitoring toxic organics in ambient air.

It is anticipated that three to five additional monitoring and measurement technologies will be funded for demonstration during the coming fiscal year. The two demonstrations completed in FY 1989 and the planned activities of the MMTP for the coming year are discussed below.

A. ACCOMPLISHMENTS

In FY 1989 the first two monitoring and measurement technologies were ready for demonstration. The two demonstrations that were conducted during the fourth quarter of this fiscal year are described below. The full demonstration reports for each of these technologies will be available in FY 1990.

The first demonstration was conducted in conjunction with the BioTrol, Inc., biological treatment technology demonstration at the MacGillis and Gibbs Superfund site in New Brighton, Minnesota. EMSL-LV tested the performance of a field immunoassay kit and a laboratory-based immunoassay for measuring pentachlorophenol (PCP) in treated and untreated groundwater. The immunoassay technique employs antibodies specific for binding to PCP. The technique is based on competition for antibody binding between a known amount of PCP from a standard solution and an unknown amount of PCP contained in water samples. The analysis is completed in 20 minutes with a detection level of 1 ppb.

The second project was a cooperative field study undertaken with the State of Delaware's Department of Natural Resources and Environmental Control. At four sites near New Castle, Delaware, comparisons between air sampling and monitoring techniques were investigated. Three of the four sites are Superfund sites, including the Army Creek Landfill, Delaware Sand and Gravel, and the Halby Chemical Site. The technologies that were investigated include canister-based samplers, Fourier Transform Infrared (FTIR) spectroscopy for long-path monitoring of ambient air volatile organics, and solid sorbant sampling and analysis. Comparisons between the canister-based and the FTIR methodologies were carried out to develop point and long-path monitoring relationships.

B. FUTURE ACTIVITIES

During FY 1990, EMSL-LV has set ambitious goals for the MMTP. One significant activity will involve gathering information from the developers of innovative monitoring and measurement technologies to develop technology profiles. The technology profiles will accomplish three purposes. First, the information gathering effort will alert developers that EPA is interested in enhancing its ability to assess the nature and extent of contamination at Superfund sites. Second, preparation of the technology profiles will encourage developers to participate in the SITE Program to obtain support for the development of technologies that can be field demonstrated, and the necessary field methods or standard operating procedures. Third, the profiles will provide an information base from which EPA can determine technologies that may be suitable participants in the Monitoring and Measurement Technologies Program and identify technology and data gaps.

It is anticipated that three to five demonstrations will be conducted under the MMTP in FY 1990. Presently, EMSL-LV is considering the following technologies for demonstration:

- An immunoassay field kit for the measurement of benzene, toluene, and xylene in soil.
- A side-by-side demonstration of field mass spectrometers.
- Data acquisition and management software for use with field portable x-ray fluorescence spectrometers.
- Sample preparation equipment for thermal desorption of VOCs from soil samples.
- HR-FT-IR spectrometer for the detection of ambient volatile organic carbon compound emissions from Superfund sites.

In addition, the MMTP is considering the following types of emerging technologies for inclusion in the program in FY 1990:

- Mercuric iodide detectors for use with field x-ray fluorescence spectrometers.
- A computer interface between a data telemetry system and geophysical and x-ray fluorescence technologies.
- Field methods for measuring hexavalent chromium in soils.
- Development of new soil sampling methods for VOCs.

Planning and coordinating the Second International Symposium on Field Screening Methods for Hazardous Waste and Toxic Chemicals will be an important activity in FY 1990. The symposium is scheduled for February 12-14, 1991 in Las Vegas, Nevada. The co-sponsors for the symposium will include the Department of Energy, the U.S. Army Toxic and Hazardous Materials Agency, and Florida State University. EMSL-LV is actively seeking the participation of other federal agencies as well. The first symposium, held in October 1988, was successful in bringing together a mix of individuals representing various federal and state agencies, technology developers, and venture capitalists to discuss rapid, in-field site characterization and monitoring technologies. The proceedings from the symposium were provided to the National Technical Information Service (NTIS) for public distribution.

During FY 1990, demonstration reports will be prepared for the immunoassay technique demonstration to detect toxics in water, and the demonstration of the air sampling and monitoring techniques. In addition to these two demonstration reports, the following two administrative documents will be finalized and available for distribution:

- Overview of the Monitoring and Measurement Technologies Program Operating under the SITE Program.
- Guidelines for Demonstrating Monitoring and Measurement Technologies under the SITE Program.

V. TECHNOLOGY TRANSFER PROGRAM

The Technology Transfer Program component of the SITE Program involves all of the community relations, information dissemination, and technical assistance activities that support the other three components of the SITE Program. The technology transfer strategy focuses on compilation and dissemination of SITE Program results to various audiences. The purpose of the technology transfer activities is the development of an interactive information exchange network that consolidates information on existing hazardous waste treatment technologies to assist those making hazardous waste remediation decisions. The primary audience of SITE Program data is regional and state managers of Superfund cleanup activities, who often supervise the work of contractors and potentially responsible parties (PRPs). Additional audiences include remediation contractors, other federal agencies, technology developers, academia, the pollution control industry, and the interested public.

The major accomplishments of the Technology Transfer Program during FY 1989 include:

- Numerous publications were prepared and disseminated including eight *Technology Evaluation Reports*, four *Applications Analysis Reports*, six SITE videos, two program status brochures, and numerous project fact sheets, bulletins, and technical papers and posters.

- EPA sponsored an international forum on innovative hazardous waste treatment technologies that was attended by over 530 representives of the United States and seven other countries. The purpose of the conference was to introduce promising international technologies through technical papers and poster displays, and to discuss the status and results of the SITE Program technologies.

- The ATTIC system became operational in May 1989 and has distributed over 400 copies of the Database and responded to over 150 requests for information. An online system was implemented in November 1989.

- EPA and the Department of Energy (DOE) signed a Memorandum of Understanding to conduct a joint demonstration under the SITE Program at a DOE facility having radioactive and mixed waste.

- A Regional SITE Coordinator's Meeting was held to identify potential demonstration sites for new technologies entering the SITE Program.

- Visitor's Days were held to observe field activities for six demonstrations and attendance ranged from 30-135 visitors.

The Technology Transfer Program encompasses a variety of public outreach and information dissemination programs and activities. The major accomplishments during FY 1989 for each of these programs and activities are discussed below.

A. ACCOMPLISHMENTS

1. SITE Reports, Videos, Brochures, and Publications

Twelve reports, including eight *Technology Evaluation Reports* and four *Applications Analysis Reports*, were completed in FY 1989. SITE reports, specifically, the *Technology Evaluation* and *Applications Analysis Reports*, are prepared following the completion of each demonstration and laboratory analyses. The *Technology Evaluation Report* is a technical report documenting the performance data resulting from the demonstration, sampling and analysis procedures, and QA/QC program. The *Applications Analysis Report* evaluates available information on the technology and presents the applicability of each technology to other sites and wastes. Copies of these reports and summaries of these reports are disseminated by EPA, and additional copies are available through the National Technical Information Service. A list of publications, including information on obtaining the documents, is provided in Appendix 1.

Press releases are issued by EPA to announce the selection of new technologies into the SITE Program, the selection of sites for demonstrations, and the results of the demonstrations. Program status memoranda are sent regularly to the regional offices and states, and the *Technology Transfer Newsletter*, published quarterly by the Center for Environmental Research Information (CERI), lists available SITE reports. Site-specific *Technology Fact Sheets* are prepared for each technology prior to the field demonstration. A sample *Technology Fact Sheet* is provided in Appendix 2.

Demonstration Bulletins are prepared for each technology after the field demonstration is completed. A sample *Demonstration Bulletin* is provided in Appendix 3. The *Fact Sheets* and *Demonstration Bulletins* are distributed in the local community and among developers, state, and regional staff. Videos of the technology demonstrations are also produced to supplement the other informational materials describing the demonstrations. Six videos were completed in FY 1989. In addition, EPA and SITE Program participants prepared and presented technical papers and posters describing innovative hazardous waste technologies at conferences, including the international forum discussed below.

SITE Program status brochures are prepared twice each year, one for the annual RREL Symposium and the other for the Superfund Conference and Exhibition. Each year approximately 500 to 900 participants attend the RREL Symposium and 3,000 participants attend the Superfund Conference. The brochures provide a brief background of the SITE Program and its components. They contain technology descriptions for the SITE Program projects, the names of EPA and developer contacts, and the progress and accomplishments of the program to date. In addition, the brochures identify contacts for further information on the SITE Program, who should apply, how to apply, what occurs under the program, and when the next solicitation will be issued. The brochures are widely disseminated at these conferences. Approximately 12,000 copies of each of these brochures were printed and distributed in FY 1989.

EPA has updated the *Superfund Innovative Technology Evaluation Program: Technology Profiles*, originally published in 1988. The document includes an overview of the SITE Program, a list of the program participants, and profiles on each of the technologies, including a description of the technology, a discussion on waste applicability, the status of the demonstration, and an EPA and technology developer contact for further information. The purpose of the *Technology Profiles* is to provide regional decision-makers and other interested individuals with a ready reference on those technologies in the SITE Demonstration and Emerging Technologies Programs.

2. International Forum on Innovative Hazardous Waste Treatment Technologies

On June 19-21, 1989, the *Forum on Innovative Hazardous Waste Treatment Technologies: Domestic and International*, sponsored by EPA, was held in Atlanta, Georgia. Over 530 representatives from the United States and seven other countries attended the conference. During this first-ever meeting of its kind, scientists and engineers, representing U.S. and international government agencies, industry, and academia attended 30 presentations describing successful international and SITE Program case studies of physical, chemical, biological, thermal, and stabilization treatment methods. International scientists and vendors presented over 40 posters explaining their treatment methods and results.

With approximately 70% of the participants from industry, the conference provided an excellent opportunity for EPA regional staff, cleanup contractors, and vendors to make contacts and to discuss the advantages and limitations of innovative technologies in order to make better choices among technologies under consideration at Superfund sites. Based on the enthusiastic response from conference participants, a second international forum is scheduled for May 15-17, 1990 in Philadelphia, Pennsylvania.

3. Clearinghouses

Alternative Treatment Technology Information Center (ATTIC)

ATTIC is a comprehensive, automated information retrieval system that integrates data on hazardous waste treatment technologies into a centralized, searchable source. It was initiated in November 1987, and a prototype version became operational in May 1989. It is presently composed of four major components: (1) a hotline, (2) an electronic bulletin board, (3) a reference library, and (4) a computerized information network. Hard copies of information are provided upon request. The ATTIC system was designed to provide information on hazardous waste treatment to a user community consisting of EPA headquarters and regional staff, participating state environmental agencies, and the numerous remediation contractors.

The information contained in ATTIC consists of a wide variety of data obtained from the SITE Program and federal and state agencies. The core of the ATTIC system is the ATTIC Database which contains abstracts and executive summaries from over 900 technical documents and reports.

In addition to the ATTIC Database, the ATTIC system serves as a "gateway" to access relevant information sources. The ATTIC system contains resident databases that had already been developed, as well as online commercial databases. The ATTIC resident databases include the RREL (Water) Treatability Database, RSKERL Soil Transport and Fate Database, EPA Library Hazardous Waste Collection, Technical Assistance Directory, Historical User File, and Online Resources--Technical Information Exchange (TIX) and OSWER Bulletin Board, Dialcom, NTIS, and RODS Database.

The major accomplishments of the ATTIC system during FY 1989 include the following:

- The ATTIC system was successfully pilot tested in the Hazardous Waste Management Division of U.S. EPA Region III.

- The ATTIC system has been successfully demonstrated in the States of California, Florida, and Washington. It has been demonstrated at four major hazardous waste conferences.

- Since the ATTIC system became operational in the prototype version in May 1989, over 150 requests for information have been received. The responses to each of these requests have been timely and met the information needs of the requestors. Over 400 copies of the ATTIC Database have been distributed throughout the user community.

- The prototype version allowed only one user access to the system at one time. In November 1989, an online system was implemented that accommodates up to eight simultaneous users.

OSWER Bulletin Board

The OSWER electronic bulletin board system (BBS), accessible by microcomputers, is intended to foster communications and technology transfer among EPA regional, headquarters, and laboratory personnel, federal, state, and local government personnel, and EPA contractors interested in solid and hazardous waste technical issues. The BBS offers up-to-date bulletins describing the current status of each of the SITE technology demonstrations. The BBS also offers messages, files and computer programs, databases, and information on conferences.

Technical Information Exchange (TIX)

EPA's Technical Information Exchange (TIX) Computerized On-Line Information System (COLIS) provides quick and easy access to the complete text of each published SITE *Applications Analysis Report*. The reports can be searched by entering keywords to locate the reports and pertinent sections. TIX disseminates technical information involving hazardous waste technologies and assists users in locating or obtaining materials from other sources (e.g., EPA's Center for Environmental Research Information).

4. Cooperative Efforts with Other Federal Agencies

EPA has conducted two internal studies of research, development, and demonstration (RD&D) needs for radioactively contaminated Superfund sites. Based on the results of these studies, EPA is pursuing potential cooperative demonstration evaluation projects with the Department of Defense (DOD) and the Department of Energy (DOE). Discussions were initiated with DOE because 11 of the 31 radioactively contaminated Superfund sites are DOE facilities. EPA and DOE are attempting to create joint projects in five areas related to hazardous and mixed waste cleanup: (1) demonstration of new cleanup technologies, (2) R&D on emerging cleanup technologies, (3) RD&D on waste minimization at DOE facilities, (4) sharing of databases, information systems, etc., and (5) RD&D on monitoring technologies. The SITE Program and the DOE Hazardous Waste Remedial Actions Program (HAZWRAP) are the mechanisms used to identify possible joint projects.

A series of meetings with DOE during FY 1989 have resulted in a Memorandum of Understanding signed in December 1989 to cover the above work effort. These meetings have also provided a forum for exchange of program information by the two agencies. It is anticipated that a joint EPA/DOE technology demonstration will be conducted in the summer of 1990. DOE has expressed an interest in three SITE technologies and efforts are underway to identify DOE proposed or listed NPL sites having mixed radioactive and hazardous wastes for demonstration projects.

5. Regional SITE Coordinator's Meetings

In an effort to speed up the site selection process, EPA initiated Regional SITE Coordinator's Meetings. The purpose of the meeting was to identify potential demonstration sites for the new technologies recently accepted from the fourth solicitation (SITE-004) and to obtain feedback from the regions on the SITE Program. The SITE-004 technologies were discussed and some sites were identified for further evaluation and discussion with the developers. The regional coordinators stressed the need for brief summaries of technologies that are results-oriented, and identified the need for more time to select appropriate sites for SITE demonstrations.

6. Seminar Series

In order to facilitate the transfer of information on alternative technologies, EPA has developed a seminar series to be presented to the regions. The purpose of the seminars is to further educate regional and state personnel on the alternative technologies in the SITE Program. The seminars are designed to present detailed information on completed SITE demonstrations in a one-day session. Each region will choose five completed demonstrations of interest to that region for the presentation. The seminar series is scheduled to be pilot tested in Region III on January 11, 1990 and Region IV on December 14, 1989. An evaluation of the seminars will be conducted prior to scheduling additional seminars.

7. Technical Assistance to Regions, States, and Cleanup Contractors

EPA SITE Project Managers are available to assist regional, state, and cleanup contractor staff in the evaluation of technologies for specific remedial/removal measures. In conducting SITE demonstration projects, the Project Managers receive operational and process information that allows them to provide quick-response technical assistance to facilitate the selection of appropriate remediation technologies.

8. Public Meetings and Demonstration Site Visits

Each regional and/or state Community Relations Officer is encouraged to hold at least one informational briefing or public meeting in the community on each demonstration site. In addition, Section 311(b)(5)(E) of CERCLA requires the establishment of a public notice and comment period prior to final selection of a demonstration site. Following the comment period, a responsiveness summary is prepared and a formal decision is made on whether to proceed with the demonstration at the proposed site. A Visitor's Day is sponsored by EPA during each SITE demonstration to allow first-hand observation of the technology during field use and discussions with the developers. During FY 1989, Visitor's Days were held for the six demonstrations listed in the following table.

DEVELOPER/ DEMONSTRATION LOCATION	DATE OF VISITOR'S DAY
Soliditech, Inc. Imperial Oil Co., Inc. Superfund Site Morganville, NJ	December 7, 1988
Ultrox International, Inc. Lorentz Barrel and Drum Company Superfund Site San Jose, CA	March 8, 1989
Chemfix Technologies, Inc. Portland Equipment Salvage Company Removal Site Clackamas, OR	March 15, 1989
Freeze Technologies Corporation Stringfellow Superfund Site Glen Avon, CA	August 23 1989
Toxic Treatments (USA), Inc. Annex Terminal Site San Pedro, CA	September 7, 1989
BioTrol, Inc. MacGillis and Gibbs Superfund Site New Brighton, MN	September 27, 1989

Attendance at the demonstration sites on Visitor's Days has ranged from 30-135 visitors. Public participation in the SITE Program is of major importance to EPA. The Agency recognizes the impact of public opinion on the remediation actions at Superfund sites and is working to identify those hazardous waste treatment technologies that offer more permanent protection of human health and the environment.

B. FUTURE ACTIVITIES

Most of the activities and programs of the Technology Transfer Program are continuous throughout each year of the SITE Program. These efforts will continue for the technology projects that are currently in the program and will be initiated for the new technologies entering the program under the SITE-005 and E-03 solicitations. EPA Project Managers will provide technical assistance on their completed demonstrations as results become available. It is anticipated that three *Technology Evaluation Reports*, six *Applications Analysis Reports*, and two combined reports will be published in FY 1990. In addition, approximately five videotapes should be produced on completed demonstrations.

The future activities for ATTIC include its expansion to serve as a true information retrieval system through the development of a centralized computer database network with online capability. Expansion of ATTIC will involve three areas of development. The most important area of development for the ATTIC system in FY 1990 will be the expansion and updating of the volume of information contained within the ATTIC Database. Additional technical information will be acquired with treatability studies receiving a high priority in light of a recent decision that ATTIC will serve as the source of all treatability study information in FY 1990. The ATTIC system hardware/software will be upgraded to support up to 32 concurrent users by August 1990. The online system will provide weekly information updates and an expert system to respond to user inquiries. The system will also support a sophisticated electronic mail system which will allow users to communicate with each other, the system operator, and laboratory experts. The system operator will be available for special purpose retrievals and user assistance.

APPENDIX 1. LIST OF PUBLICATIONS

LIST OF PUBLICATIONS
SITE PROGRAM DOCUMENTS*

Several of technical publications and SITE Demonstration Program results are available from EPA. To receive one or more of these reports, call EPA's Center for Environmental Research Information (CERI) at (513)569-7562.

GENERAL PUBLICATIONS

Technology Profiles (EPA/540/5-89/013)
Brochure - EPA Research Symposium (EPA/540/8-89/010)

PROJECT RESULTS

HAZCON, Inc.

Technology Evaluation Report (EPA/540/5-89/001a)
Applications Analysis (EPA/540/A5-89/001)

Shirco Infrared Systems, Inc.

Technology Evaluation Report - Peak Oil (EPA/540/5-88/002a)
Technology Evaluation Report - Rose Township (EPA/540/5-89/007a)
Applications Analysis (EPA/540/A5-89/007)

American Combustion, Inc.

Technology Evaluation Report (EPA/540/5-89/008)
Applications Analysis (EPA/540/A5-89/008)

Terra Vac, Inc.

Technology Evaluation Report (EPA/540/5-89/003a)
Applications Analysis (EPA/540/A5-89/003)

International Waste Technologies

Technology Evaluation Report (EPA/540/5-89/004a)

C.F. Systems Corporation

Technology Evaluation Report (EPA/540/5-89/006)

Soliditech, Inc.

Technology Evaluation Report (EPA/540/5-89/005)

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* Documents ordered through ORD Publications are free of charge.

APPENDIX 2. SAMPLE TECHNOLOGY FACT SHEET

EPA **Fact Sheet** MPCA

SITE Demonstrations of Two Technologies at the MacGillis & Gibbs Site:

1. Soil Washing with the BioTrol Soil Treatment System
2. Biological Treatment of Contaminated Water with the BioTrol Aqueous Treatment System

The MacGillis & Gibbs site has been proposed as a test site for the demonstration of two cleanup technologies under a new U.S. Environmental Protection Agency (EPA) program called the Superfund Innovative Technology Evaluation (SITE) program. The technologies proposed for testing at the MacGillis & Gibbs site were developed by BioTrol, Inc. of Chaska, Minnesota. One of the technologies was designed to treat contaminated soils; the other technology treats contaminated groundwater and wastewater. If approved, the demonstrations will occur in July or August, 1989. The purpose of this Fact Sheet is to provide information on the proposed project and solicit public comment. EPA staff will discuss the project and ask for public comments at the regular meeting of the City of New Brighton Environmental Quality Commission at 7:30 PM, April 12, at New Brighton City Hall, in Council Chamber, 803 Fifth Avenue, NW, New Brighton, Minnesota. The SITE Demonstrations will be the first topic of discussion.

What is the Problem?

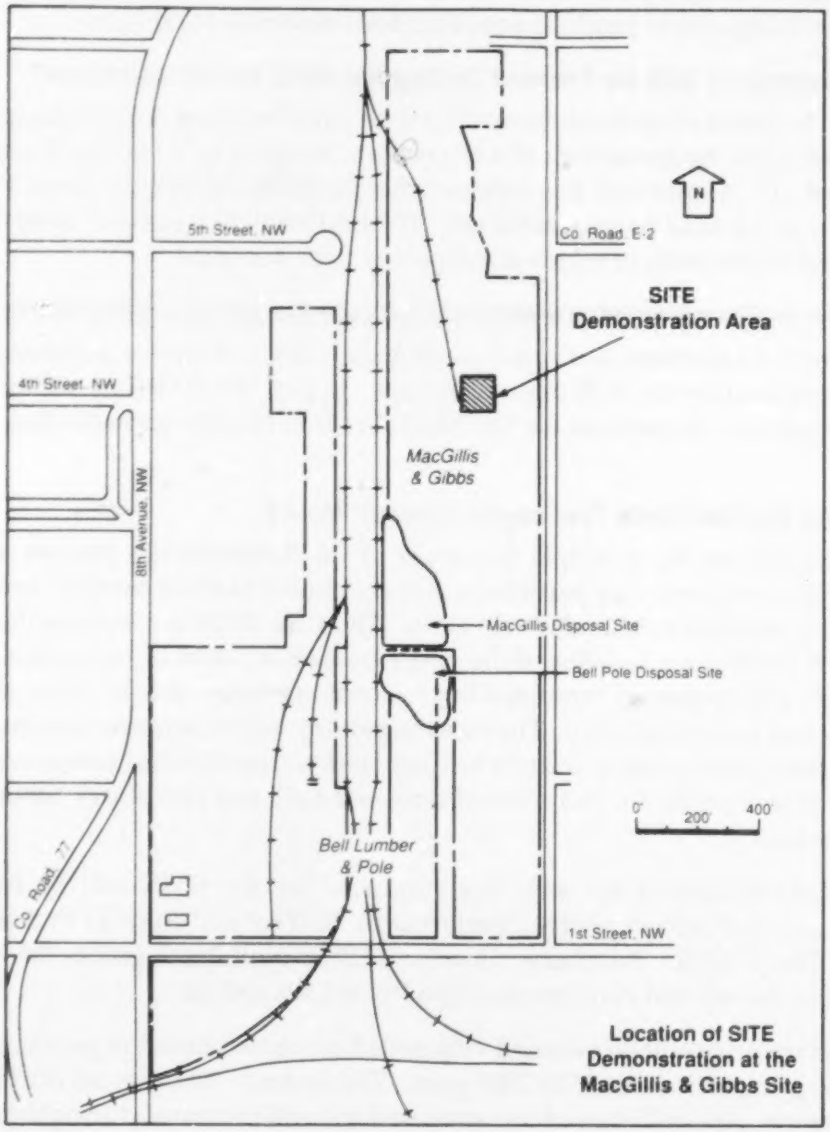
MacGillis & Gibbs, Inc. has been operating a wood treating facility on a 24-acre site in New Brighton, Minnesota since the early 1920's. Originally, a preservative known as creosote was used to treat wood products until the use of pentachlorophenol (penta) was initiated in the late 1940's or early 1950's. In 1970, MacGillis & Gibbs installed a chromated copper arsenate (CCA) pressure treating plant and currently uses only that process. Waste management practices associated with the current wood treating operations conform to current regulations. However, for many years MacGillis & Gibbs and the neighboring Bell Lumber & Pole facility disposed of wastes in a low-lying area astride the properties. The wastes included treated and untreated wood, sludge, and runoff water from the MacGillis & Gibbs treatment area. Studies show that soil throughout the two sites and groundwater under the disposal area are contaminated with the toxic chemicals used in the wood preserving process.

The MacGillis & Gibbs and the Bell Lumber & Pole sites were nominated (as a single 68-acre site) for inclusion on the EPA's National Priority List (NPL) in 1983. In 1984 the site was permanently included on the NPL. Bell Lumber & Pole entered into an agreement with the Minnesota Pollution Control Agency (MPCA) in 1985 to investigate and clean up its portion of the site. The contamination migrating from the MacGillis & Gibbs site is being studied under the auspices of both the EPA and the MPCA Superfund programs.

What is the SITE Program?

The Environmental Protection Agency is trying to find better solutions to hazardous waste cleanup through its new SITE program, which was created in response to the Superfund Amendments and Reauthorization Act of 1986. As a joint effort between EPA's Office of Research and Development and Office of Solid Waste and Emergency Response, the SITE program conducts carefully planned demonstration projects to test new ways to destroy, neutralize, or otherwise detoxify hazardous wastes.

EPA will select suitable locations for SITE demonstration projects after a nationwide search to match promising technologies with the types of wastes and conditions at selected Superfund sites. During the first two years of the SITE program approximately twenty sites across the country were proposed to test various technologies. MacGillis & Gibbs is one of the sites nominated for pilot testing of two innovative treatment technologies.


N
5th Street, NW
Co. Road E-2
SITE Demonstration Area
4th Street, NW
8th Avenue, NW
MacGillis & Gibbs
MacGillis Disposal Site
Bell Pole Disposal Site
0'
200'
400'
Bell Lumber & Pole
Co. Road 77
1st Street, NW

Location of SITE Demonstration at the MacGillis & Gibbs Site

Science Applications International Corporation (SAIC) is assisting the EPA in evaluating the BioTrol technologies. For the demonstrations at the MacGillis & Gibbs site, SAIC will sample and analyze the materials before and after treatment, and monitor operating parameters such as temperature, flow rates, and power consumption. Finally, SAIC will help the EPA conduct a performance and cost assessment for each demonstration to determine whether the technology is feasible for use at Superfund sites.

What Technologies Will Be Demonstrated at the MacGillis & Gibbs Site?

The EPA is evaluating the BioTrol Soil Treatment System (BSTS) and the BioTrol Aqueous Treatment System (BATS). The BSTS is a volume reduction step for treatment of contaminated soils. During the BSTS process, the larger particles of the soil (the sand) are separated from the smaller soil particles (silt and clay) where the contaminants concentrate. The BATS, a microbiological treatment process for destroying toxic organics, will be tested for cleanup of contaminated groundwater from under the MacGillis & Gibbs site. The BATS will also be used to degrade the toxic organics in the wastewater from the BSTS test. The objective of both treatment technologies is to produce nonhazardous materials for disposal.

Which Contaminants Will Be Treated During the SITE Demonstrations?

The BSTS will be tested on soils contaminated with wood treating chemicals including penta, polynuclear aromatic hydrocarbons (PAHs) present in creosote, and copper, chromium, and arsenic (from the CCA solution). It is expected that the BSTS will remove penta, PAHs, and the CCA metals from the sand portion of the soil. The BATS will be tested on water contaminated with penta and PAHs, both of which are expected to be removed.

Will the Proposed Demonstrations Interfere with the Studies Currently Being Conducted?

The investigations underway as a result of EPA and MPCA Superfund activities will not be delayed or disrupted by the SITE demonstrations. In fact, the SITE data will prove useful in evaluating treatment alternatives for the MacGillis & Gibbs site and selecting the remedial action.

How Does the BioTrol Soils Treatment System Work?

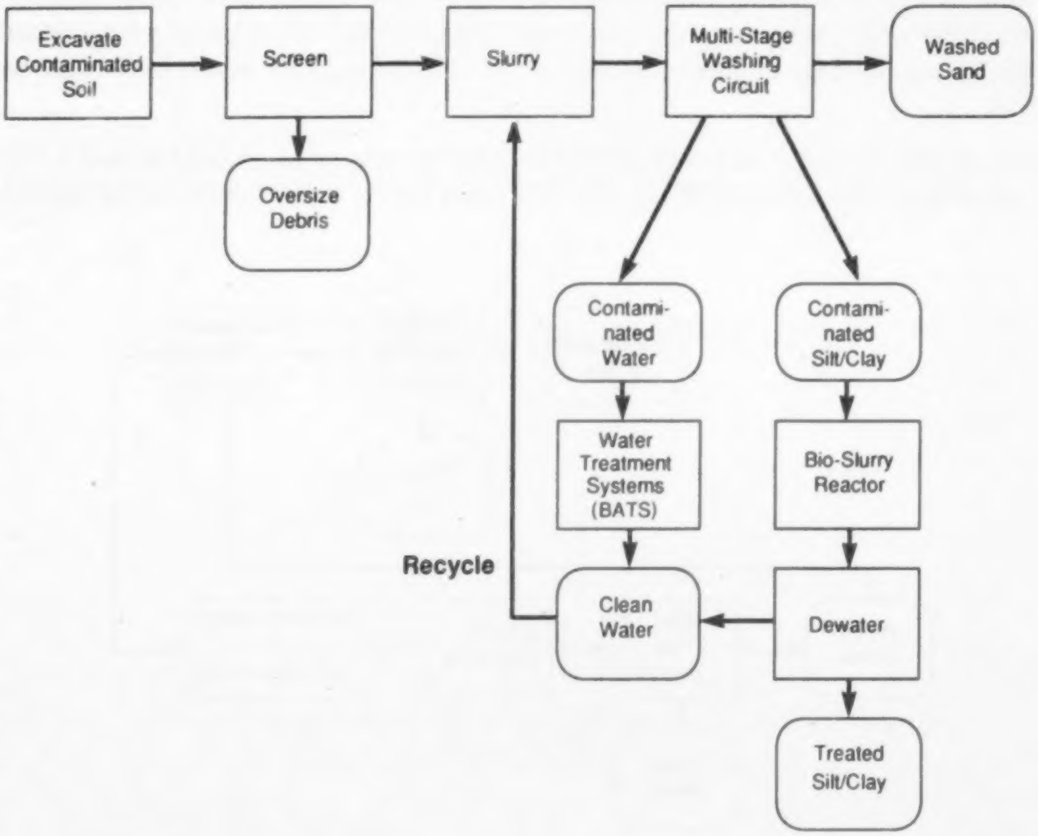
The BSTS operates on the principle that most of the contaminants present at the site are associated with the silt and clay particles and that removal of these particles leaves the rest of the soil (mostly sand particles) relatively clean. Thus, the BSTS is a waste volume reduction technology. It produces a smaller, more easily treated, amount of hazardous waste. First, excavated soils will be passed through a large screen to remove debris. Next, the soil will be mixed with water to form a slurry. The resulting slurry will be screened again and subjected to a series of intensive scrubbing and physical separation steps in a multi-stage washing circuit. The slurry will be separated into a washed sand and a silt and clay slurry containing most of the contamination.

Some of the contaminated silt and clay produced by the BSTS will be further treated biologically by a technology jointly developed by BioTrol and EIMCO Process Equipment Company. The EIMCO Bio-Slurry Reactor (EBSR) will biodegrade the contaminants concentrated in the silt and clay, producing a treated silt and clay.

The BSTS performance will be assessed with soils having two different penta concentrations: about 200-500 ppm, and about 1500-2000 ppm. The system will be tested during continuous 24-hour operation. About 75 tons of contaminated soil will be treated during the 6-8 week SITE demonstration. Because the EBSR is built on a smaller scale than the BSTS, only part of the silt and clay from the BSTS will be treated. Altogether, the soil treatment tests will produce about 62 tons of washed sand, 18 tons of contaminated silt and clay, 4 tons of washed and biologically treated silt and clay, and 8 tons of wood particles. The increase in total weight of material results from water added during the treatment. The residuals from the treatment system, including the washed sand, the contaminated silt and clay, and the biologically treated silt and clay, will be stored in drums at the site for disposal as part of the Superfund cleanup, or for disposal offsite as a hazardous waste. The washed sand and biologically treated silt and clay may be disposable offsite as nonhazardous waste.

All wastewater produced by the soil treatment system will be treated in the BATS reactor, where contaminants will be broken down by naturally occurring bacteria. If the treated wastewater meets local standards, it will be discharged to the sanitary sewer for treatment and disposal.

During 1988, a pilot test of this technology was conducted at the MacGillis & Gibbs site. The mobile pilot system, treating up to 500 pounds of soil per hour, demonstrated removal of 85 to 99 percent of the penta and PAHs from the contaminated soil. From 73 to 83 percent of the original soil was recovered as washed sand. The favorable results of this pilot test indicate that the proposed SITE demonstration should be successful.


Excavate Contaminated Soil
Screen
Slurry
Multi-Stage Washing Circuit
Washed Sand
Oversize Debris
Contaminated Water
Contaminated Silt/Clay
Water Treatment Systems (BATS)
Bio-Slurry Reactor
Recycle
Clean Water
Dewater
Treated Silt/Clay

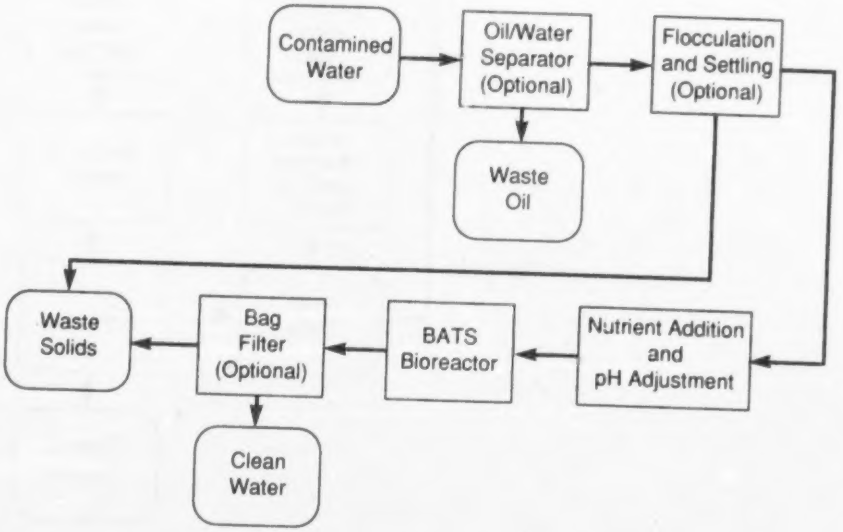
The BioTrol Soil Treatment System (BSTS)

How Does the BioTrol Aqueous Treatment System Work?

The BATS is a microbiological system, consisting of a layer of naturally occurring microbes growing on plastic support material in tanks, used for degrading toxic organic compounds in water. Under the planned SITE demonstration, BioTrol will apply the BATS process to removing the penta and PAHs from the groundwater underlying the MacGillis & Gibbs site. The contaminated groundwater may require pretreatment, such as oil/water separation (to remove floating oil) or flocculation and settling (to remove suspended solids), before passing through the BATS. The pH of the water (a measure of acidity) will be adjusted and inorganic nutrients will be added. These additions help to optimize the performance of the microbes used in the process. In the BATS bioreactor, BioTrol adds a specific naturally occurring microorganism to the microbes which already exist in the groundwater. This combination of microbes rapidly degrades the penta and PAHs into carbon dioxide, water, and inorganic chloride, which are harmless products. A bag filter will be used to capture the excess biomass which exits the bioreactor. This material consists of microbes, both alive and dead, which detach from the supports and are flushed out with the water stream. The bag filter will be replaced periodically. The small amount of residuals from the BATS, including separated oil, flocculated and settled solids, and bag filters containing biomass, will be stored in drums at the site for disposal as part of the Superfund cleanup, or properly disposed of offsite as hazardous wastes.

The SITE demonstration for the BATS will last about 60 days. A maximum of 400,000 gallons of groundwater will be treated during the test. This treated water will be further treated with carbon to remove any remaining contaminants. The water will either be recycled to MacGillis & Gibbs for use in their treatment process or sent to the sanitary sewer for treatment and disposal.

In a nine-month groundwater treatment test conducted at the adjacent Bell Lumber & Pole site from September, 1986 to May, 1987, the BATS process successfully reduced 60-100 ppm levels


Contamined Water
Oil/Water Separator (Optional)
Flocculation and Settling (Optional)
Waste Oil
Waste Solids
Bag Filter (Optional)
BATS Bioreactor
Nutrient Addition and pH Adjustment
Clean Water

The BioTrol Aqueous Treatment System (BATS)

of penta to less than 5 ppm in the treated water. At times, the residual penta was reduced to less than 0.5 ppm. PAH levels of 12 ppm were reduced to 0.5 ppm. The favorable results of this pilot test indicate that the proposed SITE demonstration should be successful.

Have Potential Environmental Effects of the Demonstration Testing Been Evaluated?

Potential effects on air quality, water quality, wetlands and other environmentally sensitive areas, and on threatened or endangered animals or plants have been evaluated. No adverse effects on human health or the environment will be caused by either of the two technologies being demonstrated.

Who Will Be at the Public Meeting?

In accordance with EPA policy, a public meeting has been scheduled for April 12, 1989 at 7:30 PM. Representatives from MPCA, EPA, BioTrol, Inc., and SAIC will be present to explain the proposed SITE demonstrations, and answer any questions that might be raised during the meeting. The general public is invited, including the citizens of New Brighton, environmental groups, and other interested parties.

When is the Public Comment Period?

The MPCA and EPA invite comments on the information presented in this Fact Sheet, as well as any materials discussed during the public meeting. The public comment period will end on May 10, 1989. Written comments should be addressed to:

Minnesota Pollution Control Agency
520 Lafayette Road
St. Paul, MN 55155
Attn: Susan Brustman

Who Can I Contact with Questions about the SITE Demonstrations?

Susan M. Brustman
Public Information Officer
Minnesota Pollution Control Agency
520 Lafayette Road
St. Paul, MN 55155
(612) 296-7769

Mary K. Stinson
Chemical Engineer
Releases Control Branch
Risk Reduction Engineering Laboratory
U.S. Environmental Protection Agency
Woodbridge Avenue (MS-104)
Edison, NJ 08837-3679
(201) 321-6683

Rhonda E. McBride
Remedial Project Manager
CERCLA Enforcement Section, Region V
U.S. Environmental Protection Agency
230 South Dearborn Street
Chicago, IL 60604
(312) 886-7242

Morris J. Anderson
Vice President, Regulatory and
Governmental Affairs
BioTrol, Inc.
11 Peavey Road
Chaska, MN 55318
(612) 448-2515

APPENDIX 3. SAMPLE DEMONSTRATION BULLETIN

United States
Environmental Protection
Agency

EPA/540/M5-89/011
October 1989

EPA

SITE
SUPERFUND INNOVATIVE
TECHNOLOGY EVALUATION

Demonstration Bulletin

Solidification/Stabilization Process

Chemfix Technologies, Inc.

TECHNOLOGY DESCRIPTION: The Chemfix technology is a patented solidification/stabilization process for treating hazardous wastes. Proprietary reagent additives may include soluble silicates and silicate-setting materials. The process is designed as a continuous operation capable of treating large quantities of wastes rapidly. The products of the process are intended to be stable, friable materials with good erosion resistance and low permeabilities. In addition, the process is intended to treat the material without a large increase in volume.

After the contaminated material is excavated and screened to remove pieces larger than 1 inch, a conveyer belt moves it from the feed hopper to the weight feeder, where it is measured. The homogenizer mixes the wastes with water to achieve the desired moisture content. The wetted material then moves to a Chemfix-designed pug mill, where it is blended with the proprietary reagents. After the material is thoroughly mixed, it is discharged and allowed to harden. The final product is a solidified mass.

WASTE APPLICABILITY: This process is designed to treat soils, sludges, and waste waters. It has been used for a variety of industrial wastes contaminated with heavy metals and organic compounds with high molecular weight.

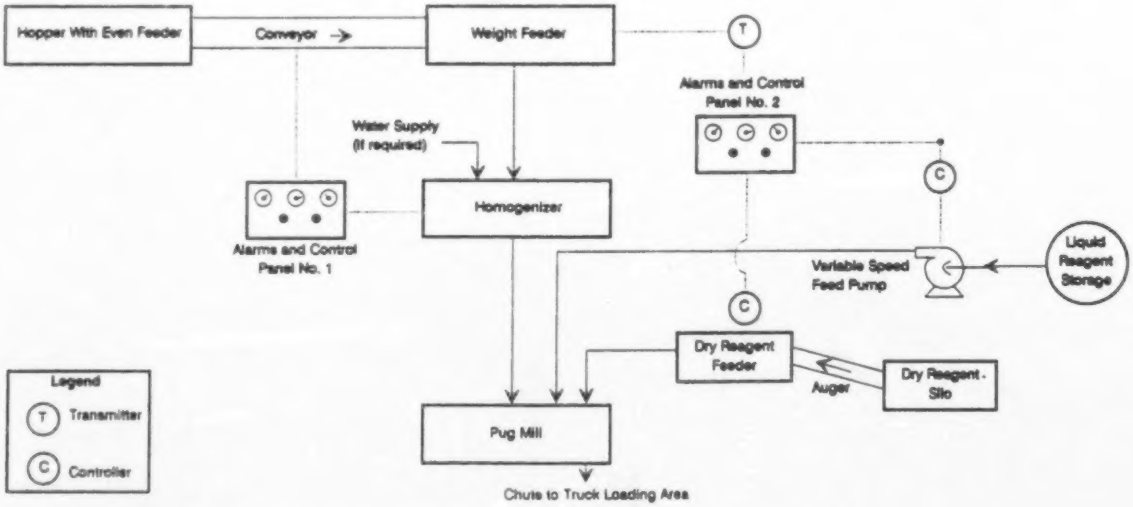

Hopper With Even Feeder
Conveyor
Weight Feeder
T
Alarms and Control Panel No. 2
Water Supply (If required)
C
Homogenizer
Alarms and Control Panel No. 1
Liquid Reagent Storage
Variable Speed Feed Pump
C
Dry Reagent Feeder
Auger
Dry Reagent Silo
Legend
T Transmitter
C Controller
Pug Mill
Chute to Truck Loading Area

Figure 1. High solids handling system block process flow diagram.

DEMONSTRATION RESULTS: EPA and the developer demonstrated this solidification/stabilization process at the Portable Equipment Salvage Company site in Clackamas, Oregon during March, 1989. The site had been used for the scrapping and recycling of transformers and metal equipment. Although the soil at the site is contaminated with a variety of pollutants, the contaminants of concern for this demonstration were lead, copper, and PCBs because they were found in the highest concentrations in the preliminary round of sampling. The equipment utilized was capable of processing soils at a rate of up to 100 tons per hour.

Several leaching and extraction tests were conducted on products of the solidification/stabilization process to indicate the long-term stability of the processed material.

The toxicity characteristic leaching procedure (TCLP) extracts from processed wastes contained lead in concentrations 94 to 99 percent less than in leachate extracts of untreated wastes. Table 1 presents a summary of the results of the TCLP tests for lead and copper.

No conclusions could be derived regarding PCB immobilization since the concentrations of PCB in the initial TCLP extracts were extremely low. PCB extraction data does show evidence of partial dechlorination of the PCBs. However, the phenomenon may not be due to the solidification/stabilization process only.

The wet/dry and freeze/thaw durability tests were very good, showing little or no weight loss after 12 cycles. The unconfined compressive strength (UCS) at 28 days ranged from 27 to 307 psi. Permeability of the treated material ranged between 1 x 10^{-6} cm/sec and 6.4 x 10^{-7} cm/sec. Table 2 presents a summary of these results of the physical tests and other chemical tests.

Other results of the demonstration include the following:

- The volume increase in the excavated waste material after treatment ranged from 20 to 50 percent.
- The air monitoring data suggest that there was no significant volatilization of PCBs during the treatment process.

A Demonstration Report describing the complete demonstration will be complete in early 1990.

FOR FURTHER INFORMATION:

EPA Project Manager
Ed Barth
U.S. EPA
Risk Reduction Engineering Laboratory
26 West Martin Luther King Drive
Cincinnati, OH 45268
513-569-7669 (FTS: 684-7669)

Table 1. Mean Concentrations of Concern from Chemfix Demonstration

	Untreated Waste (Total)	TCLP From Untreated Waste	TCLP From Treated Waste	Percent Reduction of TCLP Extractable Metal
Area A				
Lead	21,000 mg/kg	610 mg/L	<.05 mg/L	99
Copper	18,000 mg/kg	45 mg/L	0.57 mg/L	99
Area C				
Lead	140,000 mg/kg	880 mg/L	2.5 mg/L	99
Copper	18,000 mg/kg	12 mg/L	0.54 mg/L	95
Area E				
Lead	92,000 mg/kg	740 mg/L	47 mg/L	94
Copper	74,000 mg/kg	120 mg/L	0.65 mg/L	99
Area F				
Lead	11,000 mg/kg	390 mg/L	0.10 mg/L	99
Copper	33,000 mg/kg	120 mg/L	0.60 mg/L	99

Table 2. Physical and Chemical Properties of Treated and Untreated Wastes from Area C of Chemifx Demonstration

	Area C	
	Untreated Wastes	Treated Wastes
Eh (millivolts)	290	24
Conductivity (umhos/cm)	130	3200
pH	6.6	11.3-11.5
28-day UCS (psi)	N/A	27-307
Wet/dry stress weight loss	N/A	<1%
Freeze/thaw stress weight loss	N/A	<1%
Permeability (cm/sec)	10^{-4} to 10^{-6}	10^{-6} to 10^{-7}

APPENDIX 4. LIST OF ACRONYMS, ABBREVIATIONS, AND TRADE NAMES

ACRONYMS

AETS	Acid Extraction Treatment System
ATS	Aqueous Treatment System
ATTIC	Alternative Treatment Technology Information Center
BBS	Bulletin Board System
BDAT	Best Demonstrated and Available Technology
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERI	Center for Environmental Research Information
COLIS	Computerized On-Line Information System
CRF	Combustion Research Facility
CROW	Contained Recovery of Oily Waste
DCA	1,1-Dichloroethane
DOE	Department of Energy
DRE	Destruction and Removal Efficiency
EMSL-LV	Environmental Monitoring Systems Laboratory - Las Vegas
EPA	Environmental Protection Agency
ESD	Electroacoustic Soil Decontamination
FTIR	Fourier Transform Infrared
GAC	Granular Activated Carbon
HAZWRAP	Hazardous Waste Remedial Actions Program
HR-FT-IR	High Resolution Fourier - Transform Infrared
HSWA	Hazardous Solid Waste Amendments
INEL	Idaho National Engineering Laboratory
ISV	*In-Situ* Vitrification
LSCD	Liquid-Solid Contact Digestion
MMTP	Monitoring and Measurement Technologies Program
NPL	National Priorities List
NTIS	National Technical Information Service

ORD	Office of Research and Development
OSHA	Occupational Safety and Health Act
OSWER	Office of Solid Waste and Emergency Response
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PCPs	Pentachlorophenols
POHCs	Principal Organic Hazardous Constituents
PRPs	Potentially Responsible Parties
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
R&D	Research and Development
RD&D	Research, Development, and Demonstration
RFP	Request for Proposal
ROD	Record of Decision
RREL	Risk Reduction Engineering Laboratory
SARA	Superfund Amendments and Reauthorization Act
SARMs	Standard Analytical Reference Materials
SITE	Superfund Innovative Technology Evaluation
TCA	1,1,1-Trichloroethane
TCE	Trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
TEA	Triethylamine
TIX	Technical Information Exchange
TSCA	Toxic Substances Control Act
UCS	Unconfined Compressive Strengths
UV	Ultraviolet
VOCs	Volatile Organic Compounds

ABBREVIATIONS

cm	Centimeter
dscf	Dry Standard Cubic Feet
dscm	Dry Standard Cubic Meter
kg	Kilogram
lbs	Pounds
mg	Milligram
mg/l	Milligram/Liter
mm	Millimeter
NO_x	Nitrous Oxides
ppb	Parts Per Billion
ppm	Parts Per Million
psi	Pounds Per Square Inch
sec	Second

TRADE NAMES

AlgaSORB^{R}	
B.E.S.T.	Basic Extraction Sludge Treatment
CHEMFIX	
Chemtact^{TM}	
Chloranan	
Oberlin	
PACT^{R}	Powdered Activated Carbon Treatment
PYRETRON^{R}	
Tyvek^{TM}	
Ultrox^{R}	
URRICHEM	
X*TRAX^{TM}	

*U.S. Government Printing Office: 1990-748-159/00439